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# Regulatory heterogeneity and global value chain-related trade

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**Abstract**

In this paper, I estimate the impact of heterogeneity in non-tariff measures policies on countries' global value chain-related trade and its backward and forward components. I first build a regulatory distance index, which measures the degree of dissimilarity in non-tariff measure structures between two trade partners. By including the regulatory distance index in a structural gravity model, I then find a significant negative effect of regulatory distance on total, backward, and forward global value chain-related trade. The negative impact is even more substantial when I restrict the analysis to manufacturing sectors. On the country dimension, I demonstrate that the effects of regulatory distance are associated with the exporters' and the importers' income levels.

**JEL classification:** E16, F13, F14, F15, F63, L51, O40

**Keywords:** Gravity equation, gravity model, non-tariff measures, regulatory distance, trade protection, international trade, global value chains, technical regulations

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# 1. Introduction

The recent technological advancements and reductions in trade tariffs have made it increasingly profitable for firms to separate their production chain into individual stages. These tasks can then be allocated internationally to firms in countries with a comparative advantage in executing this specific portion of production, giving rise to global value chains (GVCs). According to the definition introduced by Hummels et al. (2001) and Baldwin and Lopez-Gonzalez (2015), a country is engaged in global value chains if it exports goods that are partly produced using foreign intermediates. Therefore, there is both an export and an import component to GVCs participation. In this context, as traditional trade barriers such as tariffs and quota restrictions decline in importance, the global rise in product standards (including sanitary regulations in food, technical rules in manufactures, and procedure for testing and certification) has become an important determinant of trade volume and patterns (Kinzius et al., 2019; and Inui et al., 2021). Up to 2021, 19,574 new sanitary and phytosanitary (SPS) measures and 32,593 new technical barriers to trade (TBT) were raised at the World Trade Organization[1], while the trade costs of NTMs were more than double those of ordinary customs tariffs in 2018 (UN, 2019).

The presence of NTMs and tariffs do not only affect trade in final products but also in intermediate goods and can strongly hamper countries' participation in global value chains. Indeed, intermediate goods can magnify the impact of trade costs on the economy, even more so if they are part of international multistage production (Antràs and De Gortari, 2020). We see this fact occurs for two main reasons. First, in international multistage production processes, goods cross borders multiple times; hence they may embody these additional costs each time they pass a new customs. Second, tariffs are commonly levied on a product's gross (total) import value instead of the value-added in the most recent production stage. As a result, the smaller the value-added in the last production process (relative to its gross value), the larger the effect of a trade barrier applied to this production stage (Yi, 2010).

In this context, the objective of this study is to investigate whether and how the dissimilarity in bilateral NTMs regimes can affect the countries' GVC-related trade (that is, the value of goods and services exported by a country that crosses more than one border) as well as its backward and forward components. Precisely, I first assess the average impact of NTMs heterogeneity across all sectors (excluded services), then I restrict the analysis to manufacturing industries to search for preliminary evidence of diversified effect at the sector

[1] Source: WTO SPS and TBT Information Management System.

level. Finally, I address the question of whether the regulatory distance impact is associated with the exporters' and the importers' development levels, proxied by the gross national income (GNI) per capita.

This study uses a novel approach to measure the impact that NTMs have on countries' value chains participation and international trade. Traditionally, the trade restrictiveness of NTMs has been widely computed as absolute proxies and ad-valorem tariff equivalents, which, however, fail to capture heterogeneity in trade policies (Kee, Nicita, and Olarreaga, 2009; and Korwatanasakul and Baek, 2020) and are subject to the risk of reverse causality (Franssen and Solleder, 2016). Instead, this work copes with both issues by employing a relative proxy of NTMs (Cadot et al., 2015; de Melo and Solleder, 2018; and Inui et al., 2021). More specifically, I use data on NTM measures from the UNCTAD-TRAINS database to construct a regulatory distance indicator, which measures the total bilateral dissimilarity in NTMs patterns between an exporter and its trade partner. Then, gross trade estimates from the Trade in Value-Added (TiVA) database are decomposed following the methodology proposed in Borin and Mancini (2019) to obtain yearly measures for bilateral total, backward, and forward GVC-related trade, the dependent variables of this study.

Relying upon a sample of 59 countries across 21 sectors from 2005 to 2015, I include the regulatory distance index in a structural gravity equation to empirically assess how much each of the three GVC-related trade dimensions (i.e., total, backward and forward GVC trade) is affected by a one percent increase in bilateral regulatory distance. Confounding factors and multilateral resistance terms are taken into account through the inclusion of control variables and importer-sector-year and exporter-sector-year fixed effects (Head and Mayer, 2014; Yotov et al., 2016). As a further exercise, I employ income data from the World Bank to build two additional models with two-way and three-way interaction terms. Here, the regulatory distance index is linked first with the exporter's GNI per capita and then with the exporters' and the importers' income levels. Moreover, for each model presented in this paper, I quantify the ad-valorem tariff equivalent (AVE) impact of dissimilarity in NTMs, i.e., the ad-valorem tariff whose introduction would have generated the same impact as the regulatory distance in question (Yotov et al., 2016).

This study reveals that regulatory distance negatively affects countries' GVC-related trade. According to the gravity specification we look at, a unit percent increase in the regulatory distance index can lead to a fall in the GVC-related trade ranging from 3.4% to 5.8%, a decrease of the backward GVC related-trade from 5.8% to 6.3%, and a drop of the forward GVC component of export from 3.9% to 6.6%. The overall impact is even higher when I restrict the analysis to manufacturing sectors, although participation in a regional trade agreement and cultural and linguistic ties damper this adverse effect. Considering the baseline results, the AVE of the regulatory distance index is remarkably high for the backward GVC linkages (93.3%) while substantially lower for the total and forward GVC GVC-related trade (respectively, 36.9% and 17.7%). When we look at the interaction between regulatory distance and income levels, we find that the adverse effect of bilateral regulatory distance becomes larger as the exporter's GNI per capita declines. Furthermore, the results suggest that the marginal effect of regulatory distance is substantially more negative for developing exporters addressing a low-middle or upper-middle compared to a high income importing market.

To assess the overall robustness of my findings, I also conducted a broad set of sensitivity analyses. More precisely, I first tested the methodology with which the GVC-related trade measures are built and the country sample. Then, I adopted a different approach to take into account the adjustment in trade flows. I next tested the choice of lagged trade policies variables, the lags-length, and the potential endogeneity of the regressors. Finally, I checked whether the imputation technique I performed to deal with missing values drove the results for the variable of interest. Overall, the robustness tests I implemented confirm the solidity of the findings, although the specifications having forward GVC trade as a dependent variable did not pass part of the tests, casting doubts on the overall robustness of the regulatory distance effect on the forward GVC linkages of countries' exports.

This study relates to that body of work pertaining to the economic effects of NTMs on international trade and GVCs participation. However, this work provides relevant contributions to the current literature in terms of both methodology and findings. Firstly, while the vast majority of the studies that concern the impact of NTMs focus on the trade in final goods (to cite a few, Winchester et al., 2012; Kinzius et al., 2019; Nabeshima and Obashi, 2019; and Dolabella, 2020), I employ a gravity model to assess the impact of regulatory distance on the GVC-related components of countries' exports. This aspect assumes particular relevance in the current context of globalization, where production processes are highly fragmented, and trade standards have steadily accrued. Indeed, it helps us to understand better the magnitude with which NTMs affect the countries' participation in GVCs. Second, this study includes both regulatory distance indicator and tariffs rate in a gravity model, which allows quantifying the ad-valorem tariff equivalent impact of dissimilarity in NTMs on GVC-related trade. In particular, quantifying the tariff equivalent is relevant from both a policy and a pedagogical perspective since it allows more direct comparison and comprehension of the actual impact of dissimilarity in NTMs structures. Third, it reveals the existence of heterogeneity of the regulatory distance impact according to trade actor's national income level, which has considerable policy implications in the context of regional trade agreements and South-South and North-South integration.

The paper proceeds as follows. Section 2 reviews the existing literature on the economic impact of NTMs and their effects on countries' GVCs participation. Section 3 introduces the data used in this study, the decomposition technique implemented to retrieve GVC-related trade measures from gross export data, and the methodology I followed to build the regulatory distance indicator. Section 4 presents the identification strategy employed. Section 5 begins with preliminary data observations, and it then discusses the empirical results from the baseline gravity model. Section 6 illustrates the sensitivity analysis I perform to test the robustness of the findings from the baseline model. Section 7 concludes and discusses the policy implications of this research.

# 2. Literature review

The recent growing debate on NTMs among researchers and policymakers has motivated advancement in the literature, particularly in terms of the impacts of NTMs on trade. Nonetheless, studies on the relationship between NTMs and GVC participation, or even between tariffs and GVCs, have remained limited. To the best of my knowledge, this study is the first that examines the impact of the bilateral regulatory distance on the countries' GVC-related trade within a structural gravity model framework. However, in a broader sense, this paper is grounded on previous studies concerning the economic repercussions of NTMs on trade and GVCs.

## 2.1. The economic effects of non-tariff measures

Non-Tariff Measures are generally defined as "policy measures, other than ordinary customs tariffs, that can have an economic impact on international trade in goods, affecting quantities traded, or prices or both" (UNCTAD, 2017). NTMs include a broad and diverse array of policies that countries apply to exported and imported goods. Some NTMs are manifestly implemented as instruments of commercial policy (for example, subsidies and trade defense measures), while others stem from non-trade policy purposes. The latter category includes technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) measures, which have spread significantly in the last decades. These measures are mainly implemented for legitimate and essential reasons, such as food and human safety and environmental protection. Nonetheless, they may have considerable restrictive and distorting effects on international trade, and they may be implemented as disguised protection of the local industry. However, since these policies are necessary, their elimination is not an option (Cadot et al., 2015).

Based on gravity estimations and applied general equilibrium model simulations, the literature at the broader level provides mixed evidence on the repercussions of NTMs on trade. On one hand, certain studies argue that NTMs can induce more trade (Xiong and Beghin, 2011; Rindayati and Kristriana, 2018), especially on the intensive margin (Bao and Qiu, 2012; Crivelli and Groschl, 2016). Indeed, NTMs assure the introduction of specific standards that may signal a higher quality of products. As a consequence, technical measures reduce transaction costs and can raise trade values and volumes (Beghin et al., 2012; Blind, Mangelsdorf, and Wilson, 2013). Interestingly, the trade literature demonstrates that SPS and TBT requirements, which is the focus of this paper as well, tend to decrease trade on the extensive margin but increase the volume of exports per exporting firm and even the overall performance of industries (Ghodsi and Stehrer, 2016). This fact should not be surprising since NTMs can act as a barrier to entering foreign markets, but once a firm complies with the standard, the positive quality signal can increase trade values (Beghin et al., 2012).

However, while the overall presence of NTMs has a mixed effect on trade, the impact of heterogeneity in NTMs is generally negative. To that extent, Nordås and Kox (2009) provide an overview of quantifying regulatory barriers to services trade by measuring the difference in NTMs applied between trading partners rather than the mere presence of NTMs themselves. They found that regulatory heterogeneity reduces trade in services and that harmonization of country pairs' regulation could increase the total services trade by between 13% and 30% depending on the country. Similar arguments have been applied to goods in Cadot et al. (2015) and Winchester et al. (2012). In particular, in Cadot et al. (2015), the authors construct a regulatory distance indicator and show that worldwide averages of ad-valorem equivalent (hereafter AVEs) for all NTMs together range between 5 and 27 percent across sectors. Analogously, in Winchester et al. (2012), the authors build a heterogeneity index of trade regulations and include it in a structural gravity model, finding that differences in regulations slightly reduce the agro-food trade.

## 2.2 Heterogeneity in non-tariff measures and global value chains

Traditionally, the trade restrictiveness of NTMs has been widely computed as absolute proxies (e.g., the frequency ratio or coverage ratio) and the ad-valorem tariff equivalents (Kee, Nicita, and Olarreaga, 2009). However, this typology of measures presents two crucial drawbacks. First, as Korwatanasakul and Baek (2020) highlight, they cannot capture heterogeneity in trade policies. Second, with these NTM proxies, it is possible to establish a two-way relationship where NTMs may lead to lower trade or GVC participation, while products with low trade volumes or a low degree of GVC integration may be subject to fewer NTMs (Franssen and Solleder, 2016).

To overcome these shortcomings, a recent branch of the literature has started to address the impact of the heterogeneity in NTMs rather than their mere presence. Inui et al. (2021) examine whether and how a country's centrality in GVCs is determined by its regulatory regime dissimilarity from the global average, using country and sector-level data from the Organization for Economic Co-operation and Development (OECD) and the United Nations Conference on Trade and Development (UNCTAD). Running a regression analysis, the authors find that the more similar a country's regulatory regime is to global standards, the more likely it is positioned as a key supplier of intermediates and unfinished products for the hubs downstream in the GVCs. Similarly, Franssen and Solleder (2016) provide empirical evidence of the negative effect of heterogeneity in NTMs on GVC. More specifically, the authors examined the impact of NTMs on the country's backward participation in GVCs, focusing on technical measures. By measuring a country's regulatory distance from the rest of the world using product categories (i.e., intermediates and final consumables) at the Harmonized System (HS) two-digit sector level, they find that regulatory distance on the import of intermediates is negatively correlated with export values of goods within the same value chain, proxied by the HS section. Other studies are similar in terms of approach and results (Kox and Lejou, 2005; Winchester et al., 2012; and Peters and Cadot, 2019).

While the previous researches make use of regulatory distance indicators based on that proposed in Cadot et al. (2015), another branch of the literature assesses the economic impact of the heterogeneity in NTMs structures by using an additional compliance requirement indicator, which was first proposed in Nabeshima, and Obashi (2019). In this study, the authors develop an indicator to quantify the additional regulatory requirements a country faces when exporting to a foreign country's market. The higher the value of the index, the greater the additional requirements in terms of technical measures in the destination country.

By including the additional compliance requirement indicator in a gravity equation, they estimate the impact on trade of regulatory burdens via product-level gravity equations, finding a significant negative impact on bilateral trade. Following their approach, Korwatanasakul and Baek (2020) conduct a cross-sectional analysis at the industry level, spanning 30 countries in 2015. Their analysis reveals that both NTMs and tariffs negatively impact backward GVC participation, and the impact of NTMs is even stronger than that of tariff measures. To summarize, previous studies have provided evidence that NTMs do affect international trade. Generally, this effect is mixed when we consider NTMs in absolute terms since they aim to increase the quality standards of goods and products, but overall negative when heterogeneity in NTMs is taken into account.

# 3. Data collection and regulatory distance index construction

In this section, firstly, I present the source of the data on GVC-related trade measures and the approach with which they are constructed. Then, I describe the data on technical regulations and the methodology implemented to construct the bilateral regulatory distance indicator. Finally, I explain the sources of the rest of the data included in this work.

## 3.1 Data on global value chains–related trade

Policy reforms supporting trade, a downward trend in transportation and communication costs, and exponential technological progress have eased the fragmentation of production processes across the globe, in other words, GVCs. In turn, the growth of GVCs has enabled countries to better exploit their comparative advantages by allowing them to join a production chain without supplying all the other upstream capabilities (IMF, 2016). This study employs measures of total, backward, and forward GVC-related trade as dependent variables. These three indicators are derived from the data available in the Trade in Value Added database (TiVA release 2018, OECD), and they cover 21 unique sectors across 59 countries during the years from 2005 to 2015. All three trade indicators are measured in millions of US Dollars, and they are retrieved from the World Integrated Trade Solution (WITS) portal. Table A1 and Table A2 list, respectively, the samples of countries and sectors covered by this study.

More recently, the literature started to decompose exports into distinct value-added components used to measure GVCs participation. In this paper, I make use of GVCs trade-related measures constructed following the Borin and Mancini (2019) approach, which can be considered as an extension of the Hummels et al. (2001) and Koopman et al. (2014)

methodologies. In particular, in Borin and Mancini (2019), the authors provide a new set of tools for value-added accounting of trade flows at the sectoral, aggregate, and bilateral levels that can be employed to explore a broad array of empirical questions concerning GVC-related trade and countries' participation in GVCs. They also overcome the main drawbacks that make imprecise and partially incorrect the value-added decompositions of bilateral exports previously proposed in the literature.

Figure 1 shows the Borin and Mancini (2019) extension of the Koopman et al. (2014) methodology and how they decompose the value-added components of gross exports[2]. In line with the mentioned disaggregation, we can broadly define GVC-related trade as the difference between gross and traditional trade[3], i.e., the value of goods and services that crosses more than one border. Equations (1) and (2) present a more formal definition of GVC-related trade and its sub-components:

$$GVC - related\ trade_{ijk} = Backward\ GVC_{ijk} + Forward\ GVC_{ijk} \quad (1)$$

$$Backward\ GVC_{ijk} = Pure\ Backward\ GVC_{ijk} + Two\_sided\ GVC_{ijk} \quad (2)$$

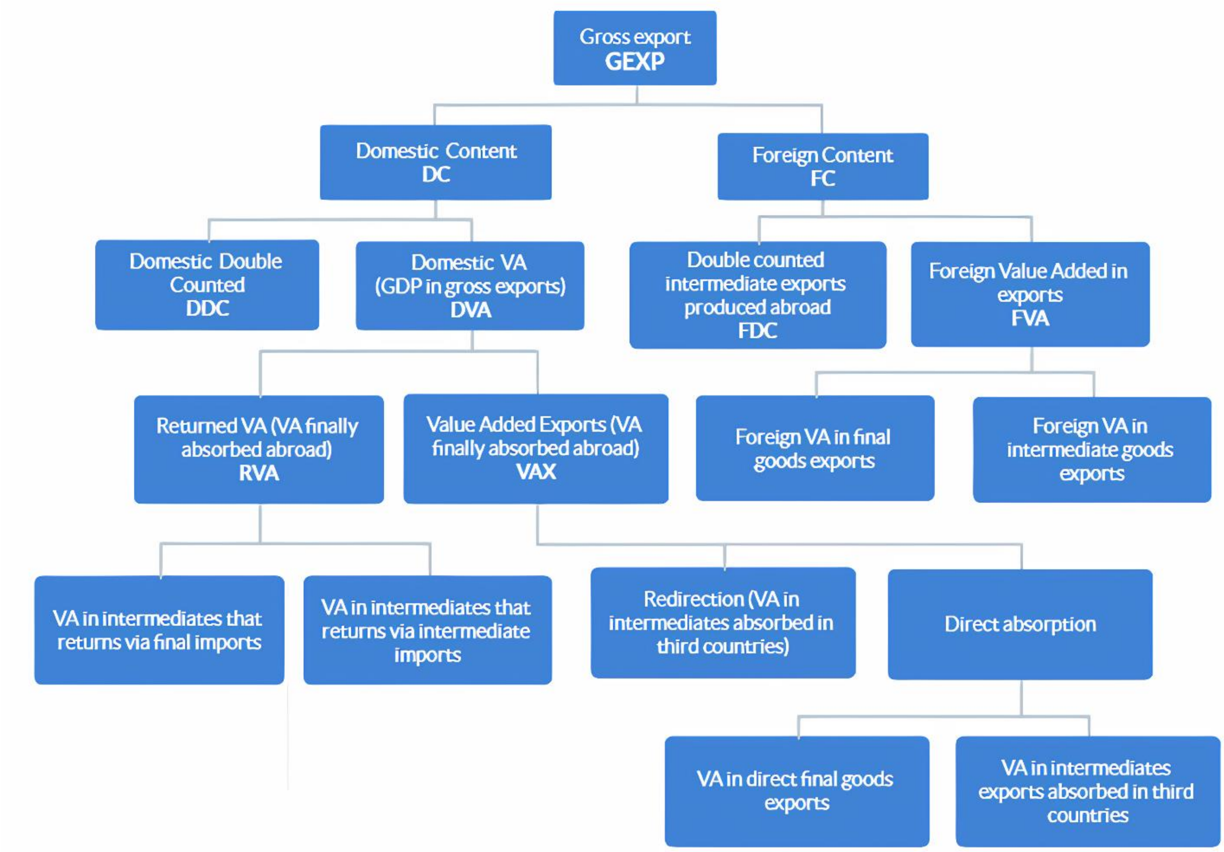
Where the $GVC - related\ trade_{ijk}$ between exporter $i$ and importer $j$ in sector $k$ can be decomposed into "backward" and "forward" components. The $Backward\ GVC_{ijk}$ participation corresponds to the sum of "$Pure\ Backward\ GVC_{ijk}$" and "$Two\_sided\ GVC_{ijk}$". $Pure\ Backward\ GVC_{ijk}$ is the value of goods and services produced with imported inputs and exported by sector $k$ of country $i$ to the final destination market, where the exporting sector is engaged in GVC activities at the end of the chain. $Two\_sided\ GVC_{ijk}$ is the value of goods produced with imported inputs, exported by the sector $k$ of country $i$ to partners, which, in turn, re-exports it to other markets; here, the exporting sector $k$ is situated in a position of the chain that is more central. More generally, $Backward\ GVC_{ijk}$corresponds to the value of import content in country $i$'s exports towards importer $j$ (in sector $k$), and it is analogous to the Vertical Specialization Index (VS) proposed in Hummels et al. (2001)[4].

[2] For more technical details on the decomposition, see Borin and Mancini (2019).

[3] Note that Borin and Mancini (2019) defines traditional trade as the value of goods and services that crosses just one border, that is, the exports whose value is entirely originated at the domestic level.

[4] For the equivalence between the backward GVCs participation and the 'import content of exports' in Hummels et al. (2001), see Borin and Mancini (2019), Appendix C. For more information on the GVC-related measures, see the data user guide available in the WITS portal.

**Figure 1:** Borin and Mancini refinement of the Koopman, Wang, and Wei breakdown of aggregate exports




Source: Author representation based on Borin and Mancini (2016).

On the other hand, $Forward\ GVC_{ijk}$ (or "pure forward GVC related-trade") is the value-added in goods entirely generated within the domestic chains of country $i$ – that is, without any border crossing – exported by the sector $k$ to partner $j$, which, in turn, re-exports it to other markets. In this case, the exporting sector is engaged in GVC activities at the origin of the chain. In other words, measures of forward GVC trade are calculated by aggregating the content of a country's domestic production assimilated into other countries' exports, and it can be considered the first correct implementation of the VS1 index suggested by Hummels et al. (2001)[5]. As highlighted in Borin and Mancini (2019), $Forward\ GVC_{ijk}$ differs from the version of the VS1 Indicator proposed by Koopman et al. (2014). Indeed, while the VS1 Index is constructed by aggregating the content of a country's production embedded in other countries' exports, the $Forward\ GVC_{ijk}$ index is a portion of country $i$'s exports (like the VS index). However, this is not necessarily true for the measure proposed by Koopman et al.

[5] To sum up, the forward linkage represents the seller-related measure or supply-side in the GVC participation index, while the backward linkage shows the buyer's perspective or the sourcing side in GVCs.

(2014). To provide an instance, suppose that a particular intermediate component exported by a country $i$ later undergoes other processing stages in different countries; the original component will be double-counted several times in the summation of country $i$'s content in other countries' exports. The difference between the original value of goods exported by $i$ and the corresponding amount that enters in the Koopman et al. (2014) indicator rises with the relative upstreamness of country $i$'s production.

Finally, $GVC - related\ trade_{ijk}$ presents three desirable features. First, once expressed as a share of gross trade, it is bounded between 0 and 1. Second, it is additive at any degree of aggregation and disaggregation of trade flows; hence data can be summed at any level to obtain the proper GVC participation measures at the desired level of aggregation[6]. Third, GVC-related trade and its backward and forward components can be considered proxies for a country's positioning in GVCs (Borin et al., 2020).

## 3.2 Non-tariff measures data collection

While the scarcity of comparable data has long hampered empirical work on the effect of NTMs, since 2011, the UNCTAD, in collaboration with several other agencies, has assembled an extensive database of NTMs, namely the TRAINS-NTMs. This global database contains detailed and comprehensive data on NTMs obtained from researchers working systematically through all laws and regulations that may affect merchandise trade in a particular country. To include NTMs measures in this study, I use the latest researcher file (v12) of the UNCTAD database, which presents collected NTMs for 92 reporters against 234 trade partners, covering 5771 products over more than a century timespan. These measures are set within a common classification framework, and they are assigned to tariff lines within the World Customs Organization's Harmonized System (HS). The policies covered by NTMs and their nomenclature are illustrated at their broadest in Figure 2. The data cover more than 90 percent of world trade and more than 100 countries (UNCTAD, 2017). All data is published online and is available through several web-portals[7].

Overall, UNCTAD–MAST Classification consists of 16 chapters (A to P). Chapters A to O concern import-related NTMs, whereas chapter P covers measures that countries impose on their exports. Another fundamental distinction is between technical measures (chapters A,

[6] For example, GVC-related trade measures can be aggregated at total country exports level, at world (sector) exports level, at country groups level, et cetera.

[7] UNCTAD–ERIA asean.i-tip.org, UNCTAD's TRAINS portal trains.unctad.org; and World Bank WITS platform at wits.worldbank.org;

**Figure 2:** UNCTAD–MAST Classification of Non-Tariff Measures

| | | | |
|---|---|---|---|
| Import-related measures | Technical measures | A | Sanitary and Phytosanitary (SPS) measures |
| | | B | Technical barriers to trade (TBT) |
| | | C | Pre-shipment inspections and other formalities |
| | Non-technical measures | D | Contingent trade-protective measures |
| | | E | Non-automatic licensing, quotas, prohibitions, and quantity-control measures |
| | | F | Price-control measures, including additional taxes and charges |
| | | G | Finance measures |
| | | H | Measures affecting competition |
| | | I | Trade-related investment measures |
| | | J | Distribution restrictions |
| | | K | Restrictions on post-sales services |
| | | L | Subsidies (excl. export subsidies) |
| | | M | Government procurement restrictions |
| | | N | Intellectual property |
| | | O | Rules of origin |
| Export-related measures | | P | Export-related measures |

Source: UNCTAD (2017)

B, and C) and non-technical measures (chapters D to O). Technical measures to trade have objectives that are not primarily trade-related, such as protecting human and animal health, but have trade impacts nonetheless. On the contrary, non-technical measures have purposes and mechanisms that discriminate against foreign producers. These can be considered non-tariff barriers as distinct from non-tariff measures. Following the main approach presented by the literature (Inui et al. 2021; Peters and Cadot 2019; Dolabella, 2020; and Franssen and Solleder 2016), this article focuses on SPS and TBT measures, for which there are 72 distinct types in the NTM classification. The distribution of SPS and TBT measures is highly concentrated in all countries, and, among all the NTMs types, they are the only ones for which a harmonization would lead to higher levels of trade and GVCs participation.

### 3.3 Regulatory distance indicator

Following Cadot et al. (2015), I measure the distance in regulatory patterns as the difference between the structures in which two countries impose NTMs, classified according to the UNCTAD-MAST nomenclature, across products. More specifically, I look at whether two countries apply the same NTM types to the same products in a given year. Borrowing an instance provided in Cadot et al. (2015), suppose that country *i* imposes NTM B840 (TBT inspection requirements) on the product HS 840731 (spark ignition reciprocating piston engines of a type used for the propulsion of vehicles of a cylinder capacity not >50cc). If country *j* also applies B840 on HS840731, countries *i* and *j* have a "similar" regulatory structure for the given measure-product pair, and the regulatory distance is zero. By contrast, if country *j* does not impose B840 on that product and implements either no NTM or instead, say, B810 (i.e., product registration requirements), countries *i* and *j* are considered as "different" for that particular measure-product pair and the regulatory distance variable takes the value of one. Formally, the distance in regulatory structure or, more simply, "regulatory distance" can be expressed and aggregated as follows. The specific NTM type ($l$) imposed by an importing country (*j*) to a specific product ($k$) coming from an exporting country (*i*) in a given year ($t$) is defined as a "dummy" variable[8]:

$$n_{jikt}^{l} = \begin{Bmatrix} 1, \; if\ country\ j\ applies\ NTM\ type\ l\ to\ product\ k\ from\ origin\ i\ in\ year\ t \\ 0, \; if\ no\ such\ NTM\ is\ applied \end{Bmatrix} \quad (3)$$

The regulatory distance measure at the measure-product level in year *t* is then:

$$RD_{lkt} = \left| n_{jikt}^{l} - n_{ijkt}^{l} \right| \quad (4)$$

If both countries implement the same measure for a particular product, the regulatory distance is 0; if they do not, the equation yields 1. To inspect regulatory patterns, I then aggregate the regulatory distance variable over all measures and all products to get an overall measure of dissimilarity. Formalizing the definition again, I estimate the distance in regulatory structures between countries *i* and *j* in year *t*, $RD_{jit}$, using the following equation:

[8] In some instances, an importer applies several different regulations classified under the same NTM code (for example, two different certificates – a health certificate and a veterinary certificate). In such cases, only a "1" is still counted for this importer–product–NTM combination.

$$RD_{jit} = \frac{1}{N} \sum_{k}^{K} \sum_{l}^{L} \left| n_{jikt}^{l} - n_{ijkt}^{l} \right| \quad (5)$$

Where $N$ is the total number of product-NTM combinations, $L$ is the number of all different NTM types that I aggregate, and $K$ is the number of different products over which the average is built.[9] In its entirely, $RD_{jit}$ corresponds to the sum of the absolute values of the differences in NTMs application. Instead, as an individual term, $RD_{lk}$ is either zero (when both $i$ and $j$ apply a given NTM to the same product) or one (when one of the two trade partners imposes a measure that the other does not on a given product). Because the total amount of product-NTM combinations normalizes the regulatory distance, the index lies between zero and one, and it is typically a small number. It is essential to point out that this index does not tell how much two countries are regulated; instead, it only measures relative positions of similarity. Nevertheless, the approach is highly flexible, and the regulatory distance can be disaggregated to a product or sector level. Indeed, comparisons can be made between two or more countries, regional trade agreements, or regional groups can be benchmarked against each other. The index can also address specific groups of NTMs only (Cadot et al., 2015). For this study, I compute the yearly bilateral regulatory distance for each trade-partners pair separately, focusing on SPS and TBT measures.

Data for this variable present a considerable number of missing values. More precisely, we see missing observations for European Union and non-EU trade partner pairs for 2005, 2006, 2007, 2008, and 2011 and South Korea from 2005 to 2009. Given the pattern, I opt for a linear interpolation algorithm to impute missing values (Bacchetta et al., 2012)[10], which finds the value y at x by detecting the closest points $(x_0, y_0)$ and $(x_1, y_1)$, such that $x_1 > x$ and $x_0 < x$ where $y_0$ and $y_1$ are observed and calculating:

$$y = \frac{y_1 - y_0}{x_1 - x_0} (x - x_0) + y_0 \quad (6)$$

When $(x_1, y_1)$ and $(x_0, y_0)$ cannot be found on both sides of x, the same formula applies to the two closest points on the same side of x. As shown in Table A 3 and A 4 in the Appendix, the summary statistics of the regulatory distance index do not change significantly after

[9] $L$ refers to the total of all 72 possible SPS and TBT measure types; $K$ refers to all unweighted products in the respective sectors (all products, agriculture, mining, and manufacturing).

[10] Note that in Bacchetta et al. (2012) the authors warn agaisnt interpolating trade data that have an high degrees of disaggregation. However, this is not the case for the current dataset, which is at the two-digit sector level.

performing the linear interpolation, while the missing values drop drastically from 23.92% to 0.11%.

## 3.4 Other data and variables for gravity analysis

In addition to the regulatory distance indicator, which is a trade flow direction-specific variable, I also gather data that account for international trade costs. These data mainly come from the Centre d'Études Prospectives et d'Informations Internationales (CEPII) Gravity database, the TRAINS database through the WITS portal, and the World Bank database. The CEPII Gravity database provides a large set of data typically used in structural gravity analysis for any country pair existing between 1948 and 2019. These variables include information on geographical distance, including distances that reflect the within-country spatial distribution of activity; dummy variables on trade facilitation measures, such as GATT/WTO membership, the existence of regional trade agreements, and the nature of these agreements; as well as dummy variables on cultural proximity such as language, religion, origins of the legal system, colonial ties, et cetera. To account for bilateral, sectoral-specific trade costs, I also gather data on the bilateral Effectively Applied Tariffs from the UNCTAD TRAINS database. The applied tariffs rate is based on Revision 3 of the International Standard Industrial Classification (ISIC 3), and they are aggregated at the two-digit level for a total of 35 sectors. This study also relies on measures of national income per person, or GNI per capita, calculated using the World Bank Atlas method. GNI per capita is measured in current US dollars, and data for this variable are retrieved from the World Bank Database.

To properly merge applied tariff rates with the rest of the data, some adjustment is needed. Firstly, the former suffers from a relevant share of missing values (approximately 53 percent). Instead of carrying out an imputation based on an econometric approach, I treat them as follows. For all importer-exporter pairs belonging to the European Union, I replace bilateral tariffs equal to 0. Then, for all EU importers, I replace their applied tariffs equal to that of the European Union as a whole towards the specific extra-EU exporter. This approach is justified by the fact that there are no tariffs or non-tariff barriers between members of the customs union and, differently from a free-trade area, members of the customs union impose a common external tariff scheme on all products entering the union (Erskine, 2006). Finally, I replace the remaining missing values with the weighted average most-favored-nation (MFN) tariffs rate[11].

[11] Data on weighted mean most favored nations tariff rate are gathered from the World Bank database.

Secondly, data on GVCs participation and tariffs are based on two different sector classifications, TiVA and ISIC revision 3, respectively. Therefore, a harmonization to a common classification is needed to merge them. Based on the "concordance" package provided by Liao et al. (2020), I harmonize applied tariffs from ISIC Revision 3 to ISIC Revision 4. Then, following the guidelines provided in the TiVA indicators guide, I match the sectors from ISIC Revision 4 to TiVA Classification. Table A3 and Table A4 in the Appendix provide descriptive statistics and display the number and proportion of missing values for each of the variables used in this research.

## 4. Gravity model and identification strategy

In this sub-section, I present the econometric strategy I execute to assess the impact of bilateral regulatory distance in non-tariff measures on total, backward and forward GVC-related trade. This study uses a structural gravity equation and extends it to the sector level, as suggested by Kinzius et al. (2019) and Yotov et al. (2016)**.** Then, following the seminal work of Santos Silva and Tenreyro (2006), I opt for the fixed effects Poisson Pseudo Maximum Likelihood (PPML) estimator[12]. Indeed, there are several reasons to prefer this estimator over the others proposed in the literature. Firstly, in the presence of heteroscedasticity, the parameters of log-linearized models estimated by OLS lead to biased estimates of the actual elasticities, distorting the interpretation of the model. These biases might be critical for the comparative assessment of economic theories and the evaluation of the effects of different policies (which is the aim of this study as well). By contrast, the PPML estimator is robust to the different patterns of heteroscedasticity.

The second source of concern rises from the high quantity of zeros typically present in trade data. Over the years, the trade literature has proposed several techniques to deal with this problem. Among others, the exclusion of $Trade_{ij} = 0$ from the dataset or the arbitrary substitutions of small numbers with zeros such as $1,000 or the minimum unit. However, these procedures will generally lead to inconsistent estimators of the parameters of interest[13]. By contrast, the employment of the PPML estimator represents an effective and convenient

[12] The model is estimated in the statistical software Stata using the command "ppmlhdfe" (Correia et al. 2020).

[13] Excluding observations in which trade equals zero leads to a sample-selection problem since very small countries would be inevitably left out from the dataset. Similarly, the arbitrary substitution of zeros with small amounts leads to results that depend on the units of measurement, and as a consequence, the interpretation of the gravity coefficients as elasticities are lost. Frankel (1997) and Yotov et al. (2016) provide a more comprehensive description of the major approaches to dealing with trade zeros and the corresponding drawbacks.

solution to the presence of zero trade flows since it allows to estimate the gravity model in its multiplicative form instead of the logarithmic form (Santos Silva and Tenreyro, 2006).

Equation (7) presents the baseline specification, which is an adaption of the traditional gravity model in its multiplicative version to match the framework of this study:

$$GVC_{ijt}^{k} = \exp[\,\beta_0 + \beta_1 \ln(1 + RD_{ijt-1}) + \beta_2 \ln(1 + Tariff_{ijt-1}^{k}) + \beta_3\, RTA_{ijt-1} + \beta_4 \ln(Dist_{ij}) + \theta_{ij} + \delta_{it}^{k} + \gamma_{jt}^{k}\,] \times \varepsilon_{ijt}^{k} \quad (7)$$

Where $GVC_{ijt}^{k}$ refers to either total, backward, or forward GVC-related trade (measured in millions of USD) between exporter $i$ in industry $k$ and importer $j$ in year $t$. $RD_{ijt-1}$ identifies the regulatory distance between countries $i$ and $j$ in year $t-1$. $Tariff_{ijt-1}^{k}$ consists of the average effectively applied tariffs rate imposed from country $j$ to country $i$ in sector $k$ in year $t-1$. $RTA_{ijt-1}$ is a dummy variable equal to 1 if trade partners $i$ and $j$ are part of a regional trade agreement in year $t-1$, 0 otherwise; $\ln(Dist_{ij})$ is the log of the population-weighted distance between the two most populated cities (in km) of countries $i$ and $j$. $\theta_{ij}$ corresponds to a set of time-invariant variables (mostly dummy variables) typically employed in gravity models indicating contiguity, common language (official and second languages), colonial ties (direct and indirect links), common legal origins (post-1991), whether common legal origin changed in 1991, and the religious proximity. $\delta_{it}^{k}$ and $\gamma_{jt}^{k}$ are exporter-sector-time and importer-sector-time fixed effects, respectively. $\varepsilon_{ijt}^{k}$ is the stochastic error term.

Some aspects of the underlying model specification deserve a more in-depth explanation. Following Yotov et al. (2016), Kinzius et al. (2019), and Dolabella (2020), all trade policy variables[14] are lagged by one year for three reasons. First, by using annual trade data, the analysis cannot control the exact date of implementation of each policy. Therefore, if we consider, for instance, tariffs and NTMs without lagging, the estimates might be biased towards zero, resulting in an underestimation of the potentially adverse effect[15]. Secondly, as argued in Ghodsi et al.(2017), it is reasonable to assume that intermediate goods react with a delay to changes in trade costs. For this reason, using lags ensures that we account for adjustments in trade flows, which do follow only after some time of adaptation.

Third, a widely-known challenge in the gravity model is to properly account for the endogeneity in trade policies variables because they may correlate with unobservable cross-

[14] i.e., the regulatory distance index, the tariff rate variable, and the variable RTA.
[15] The same reasoning also applies to the regional trade agreements variable, although in this case, we would see an underestimation of the positive treatment effects instead.

sectional trade costs (Yotov et al., 2016). For instance, the $RTA_{ij}$variable may suffer from "reverse causality" because, ceteris paribus, a given country is more likely to liberalize its trade towards a trade partner with which has a solid economic integration. Although the regulatory distance indicator is less likely to suffer from endogeneity and reverse causality (Franssen and Solleder 2016), this issue persists for the variables $Tariff_{ij}^{k}$ and $RTA_{ij}$. Therefore, following Allard et al. (2016), Tinta (2017), Ghodsi et al.(2017), and Dolabella (2019), I take the lagged values of trade policies variables in order to lessen this problem. Moreover, as suggested in Kinzius et al. (2019), I replicate the model using contemporaneous values as a robustness check, obtaining similar results.

Modeling the gravity equation explicitly with tariffs avoids omitted variable bias since, as shown by Cheng et al. (2015), tariffs negatively impact GVC trade. Moreover, I include tariffs and the regulatory distance indicator in logarithm forms, $\ln\left(1+\ RD_{ijt-1}\right)$ and $\ln\left(1+Tariff_{ijt-1}^{k}\right)$, so that $\beta_1$ and $\beta_2$ provide a direct estimate of the trade elasticities for these two variables, and their trade effect can be directly compared. Then, based on Yotov et al. (2016), for each of the specifications presented in this study, I translate the effect of regulatory distance into ad-valorem tariff equivalent effects (AVEs), i.e., the ad-valorem tariff rate whose introduction would have generated the same impact as the regulatory distance in question. Equation (8) formalizes the AVE estimation for the bilateral regulatory distance variable:

$$AVE_{RD} = \left[e^{\hat{\beta}_{RD}/\hat{\beta}_{Tariff}} - 1\right] \times 100 \tag{8}$$

Where $\hat{\beta}_{RD}$ and $\hat{\beta}_{Tariff}$ are the estimated coefficients associated with regulatory distance index and Tariffs specified in equation Eq. (7), respectively.

When estimating the gravity equation, one primary concern is to properly account for multilateral resistance terms (Baldwin and Taglioni, 2006). I do so by including importer-sector-year and exporter-sector-year fixed effects (Head and Mayer 2014; Yotov et al. 2016). These directional fixed effects absorb not only multilateral resistances but also all economic size terms, like production and expenditures. For instance, these sets of fixed effects control for differences across countries in the expenditure of domestic consumers and differences in economic size, which is an important determinant of importers' market access. They also absorb changes in productivity that are sector-specific and vary over time, such as a new production technology adopted in a specific country. Finally, these sets of fixed effects control also for time-invariant country-product characteristics.

Given this identification, we can interpret the estimated coefficient of the regulatory distance index as the average percent change in bilateral-sectoral-yearly GVC-related trade from exporter $i$ in sector $k$ to importer $j$ caused by the increase of one point percent in the bilateral regulatory distance (in year $t - 1$). This interpretation remains valid for the coefficients of all logged regressors, which are elasticities and do not need a transformation to be interpreted. For regressors not in logs (i.e., dummy variables and the Religion Proximity Index), the following formula yields the semi-elasticity: $\%\, change = (e^{\hat{\beta}_x} - 1) \times 100$; where $\hat{\beta}_x$ is the coefficient of the not logged variable $X$. This is negative for negative betas and positive for positive betas. Moreover, it approximately equals $100 \times (\hat{\beta}_x)\,\%$ for betas close to zero.

# 5. Empirical results

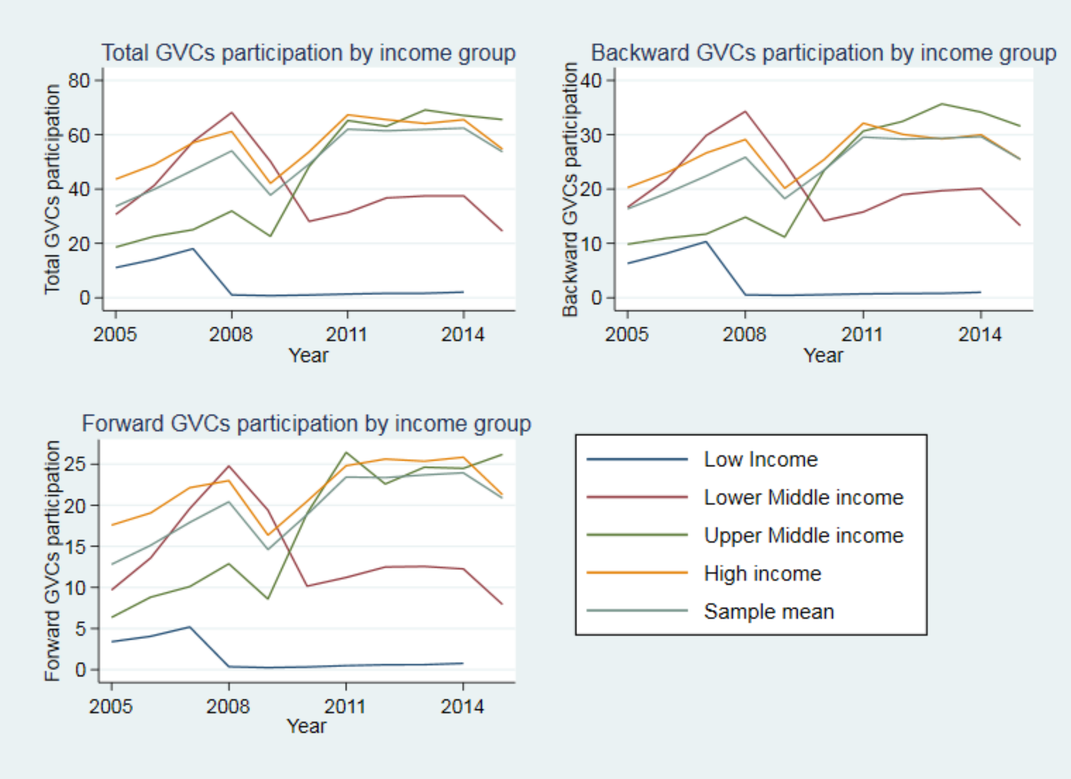
This section begins with a preliminary data observation of GVC-related trade measures and regulatory distance by exporter-income groups. Then, I will present the results from the structural gravity model baseline.

## 5.1 Development of regulatory distance and GVC-trade measures

Based on the World Bank income classification, I rank exporters into four income groups: low-income (L), lower-middle income (LM), upper-middle (UM), and high-income (H) countries[16]. Figure 3 plots the development of total, backward and forward GVC participation by the exporter income group from 2005 to 2015. For all three measures of GVCs participation, high-income exporters enjoyed a higher integration in value chains in 2005. In 2008, the global financial crisis worldwide hit the participation in international value chains, although we see remarkable differences in the magnitude across exporter-income groups. Indeed, for all three GVC-related trade measures, the lower-middle-income countries were those who more heavily suffered in terms of GVC trade, contrary to upper-middle-income exporters, for whose GVC-trade measures sharply rose after 2008. Finally, considering the most recent years, upper-middle-income countries gained a larger share of GVCs participation, not only with respect to the lower-income but also developed economies.

[16] The income classification is based on the national income per person, or GNI per capita, calculated using the World bank Atlas method. To provide a benchmark, for the year 2010, low-income countries are defined as those with a GNI per capita of $1,005 or less in 2010; lower-middle-income countries are those with a GNI per capita between $1,005 and $3,975; upper-middle-income economies are those between $3,975 and $12,275; high-income economies are those with a GNI per capita of $12,275 or more.

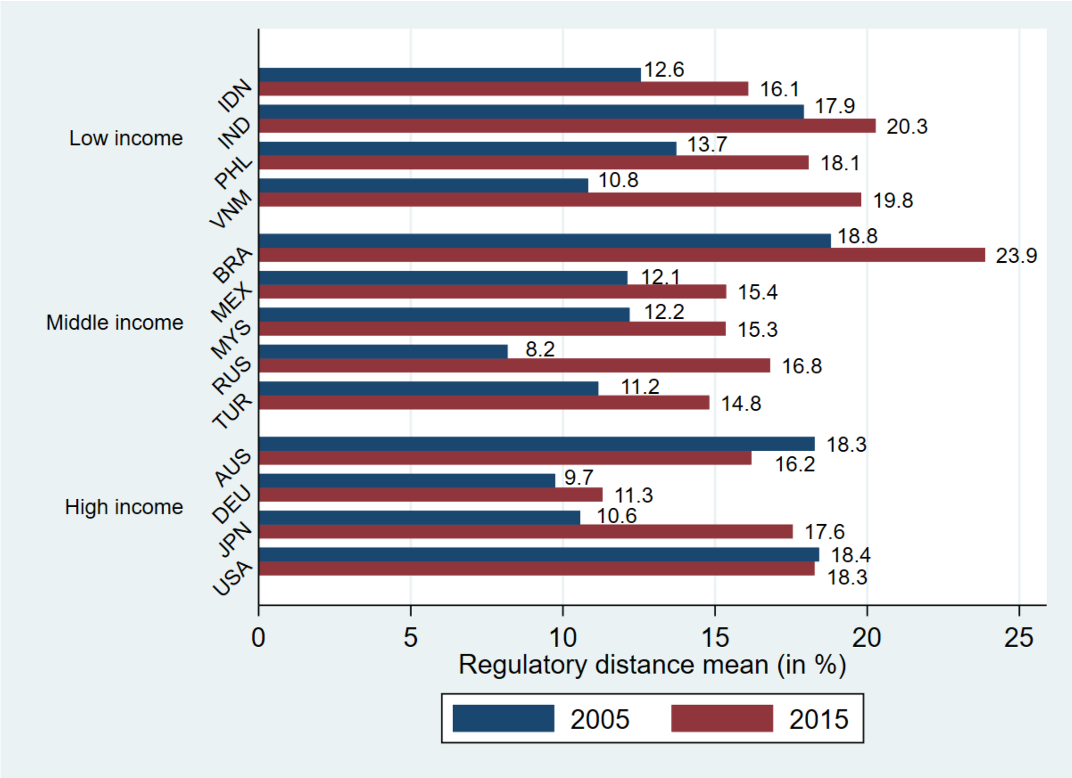
**Figure 3:** Evolution of total, backward, and forward GVCs participation per income-group




Notes: bilateral GVCs measures are averaged by exporter income groups with respect to all the trade partners. GVC-related trade indicators are measured in millions of USD. The timespan takes into account the years from 2005 to 2015. Source: Author's calculation.

Considering the regulatory distance in NTMs, Figure 4 shows the degree of heterogeneity in technical measures for some selected economies by income groups in 2005 and 2015. Overall, the figure shows how regulatory distance has increased more for developing economies than high-income countries. This fact should not be surprising for at least two reasons. Firstly, in parallel with the increase in living standards, developing economies also raise the quality standards of both intermediate and final goods, and, in the absence of trade agreement, the heterogeneity with respect to their trade partners as well. In other words, there exists a positive correlation between the level of development and regulatory heterogeneity in trade policies (Franssen and Solleder, 2016). Secondly, harmonization of new standards in trade is more likely to occur in high-income countries where firms may have stronger financial bases to comply with the foreign NTMs policies. Figure A1, which shows the regulatory distance development per income group, seems to confirm this intuition. Indeed, we see that low-income exporters experience, on average, the highest values of regulatory distance over the whole timespan, while high-income exporters have the lowest. Annex B provides gravity analysis-based evidence on the association between the effect of regulatory distance and the exporters' and the importers' income levels.

**Figure 4:** Evolution of regulatory distance for selected exporters




Notes: the bilateral regulatory distance is averaged among all the trade partners for the above-presented countries. Based on the World Bank's Income Classification, exporters are classified by GNI per capita. The low-income group includes the low- and low-middle income groups; middle-income corresponds to the upper-middle income group, and high-income corresponds to the high-income group.

## 5.2 Gravity estimation results

Baseline estimation results from Eq. (7) are reported in Table 1. Columns (1) to (3) present the gravity model results on total, backward, and forward GVC-related trade, for all sectors. According to the specification in column (1), the bilateral total GVC-related trade from exporter $i$ to importer $j$ decreases on average by 5.2% following the rise of 1% in the bilateral regulatory distance in year $t$ – 1. This effect is significant at the 1% level. The average ad-valorem tariffs equivalent effect (AVE) of the regulatory distance (RD) index amounts to 36.92%, meaning that the average regulatory distance in question would generate the same impact as a tariff rate of 36.92%. The effect of the Tariff variable is remarkably higher than that of the regulatory distance index. Indeed, an increase of 1% in tariffs in importer $j$ in year $t$ – 1 would cause an average drop of 16.5% of total GVC participation in bilateral exports of country $i$ to the importing economy $j$. Also, for this variable, the effect is significant at the 1% level. Particularly relevant in this context is the establishment of a regional trade agreement. With a coefficient statistically significant at a 1% level, membership in a regional trade agreement (RTA) in year $t$ – 1 would augment the total GVC trade of roughly 11.40%.

**Table 1:** baseline: the effect of regulatory distance (RD) on countries' GVC-related trade

| Sectors considered | All sectors | | | Manufacturing | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Dependent variable | Overall GVCp | Backward GVCp | Forward GVCp | Overall GVCp | Backward GVCp | Forward GVCp |
| ln(1 + RD) | -.052*** | -.063*** | -.043** | -.083*** | -.071*** | -.103*** |
| | (.016) | (.017) | (.021) | (.015) | (.017) | (.018) |
| ln(1 + tariff) | -.165*** | -.093*** | -.266*** | -.095*** | -.07*** | -.141*** |
| | (.02) | (.02) | (.027) | (.019) | (.021) | (.021) |
| RTA | .108*** | .191*** | .045 | .149*** | .209*** | .117** |
| | (.036) | (.036) | (.05) | (.036) | (.037) | (.048) |
| Log Distance | -.809*** | -.814*** | -.805*** | -.774*** | -.802*** | -.729*** |
| | (.022) | (.023) | (.027) | (.021) | (.024) | (.024) |
| Contiguity | .3*** | .27*** | .337*** | .288*** | .256*** | .33*** |
| | (.029) | (.033) | (.035) | (.029) | (.034) | (.029) |
| Common-language | .144*** | .149*** | .138*** | .143*** | .152*** | .126*** |
| | (.037) | (.037) | (.049) | (.038) | (.038) | (.047) |
| Common colonizer | -.234** | .15 | -.466*** | -.185 | .135 | -.4** |
| | (.116) | (.093) | (.163) | (.116) | (.096) | (.164) |
| Religion proximity | -.033 | -.108* | .059 | -.06 | -.098* | -.009 |
| index | (.055) | (.057) | (.077) | (.053) | (.058) | (.057) |
| Colonial-tie | .073 | .071 | .013 | .07 | .056 | .029 |
| | (.087) | (.09) | (.108) | (.089) | (.092) | (.106) |
| Common legal origin | .263*** | .258*** | .286*** | .252*** | .256*** | .26*** |
| | (.024) | (.026) | (.031) | (.024) | (.027) | (.026) |
| Legal origin changed | -.102** | -.136*** | -.108** | -.12*** | -.144*** | -.144*** |
| | (.04) | (.042) | (.053) | (.038) | (.043) | (.043) |
| Same colonizer | -.106 | -.117 | -.153 | -.029 | -.094 | .031 |
| | (.08) | (.076) | (.108) | (.079) | (.078) | (.095) |
| _cons | 12.942*** | 12.429*** | 12.229*** | 12.647*** | 12.387*** | 11.397*** |
| | (.178) | (.194) | (.234) | (.177) | (.199) | (.205) |
| Pseudo $R^2$ | .914 | .92 | .912 | .92 | .92 | .922 |
| RESET Test | 0.348 | 0.644 | 0.152 | 0.045 | 0.539 | 0.745 |
| $AVE_{RD}$ | 36.92 | 96.31 | 17.72 | 139.70 | 176.36 | 108.38 |

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer-sector level. Variables for RD, tariffs, and RTA are lagged by one year. All regressions include exporter-sector-year and importer-sector-year fixed effects. Standard errors are in parentheses. *Significance levels: *** p<.01, ** p<.05, * p<.1*

Despite a long-term dropping in transportation costs, distance and contiguity still remain influential factors in value chain integration. While a 1% increase in (population-weighted) distance between the two most populated cities is associated with an 81% decrease in the dependent variable, contiguity between two countries increases on average the integration in the value chain of country *i* by approximately 35%. Finally, cultural factors also play a role in this context. Indeed, both common language and common legal origins have a positive and statistically significant effect on the total GVC-related trade.

In columns (2), I conduct the analysis on the backward GVC indicator, namely, on the import content of exports of country *i* to country *j* (in sector *k*). Interestingly, regulatory distance has a more substantial impact on the backward linkages of exports than on the total GVC-related trade. Indeed, one point percent increase in bilateral regulatory distance in year $t-1$ is associated with a 6.3% fall in the backward participation of exports of country *i*, while the ad-valorem tariff equivalent is 96.31%. The effect is statistically significant at the 1% level. On the contrary, the estimated elasticity for the variable Tariff is lower than the previous specification (– 0.093) but still highly significant (s.e. = 0.02). Again, RTA and common language present positive and statistically significant coefficients at the 1% level.

Column (3) presents the results on pure forward GVC related-trade, that is, the domestic value-added re-exported by the trade partner(s). Among the three dimensions of bilateral-sectoral trade, the forward linkages are those less affected by the bilateral dissimilarity in NTMs structures. Indeed, the elasticity of the regulatory distance index in year t – 1 is just – 0.043 (s.e. = 0.021), with an associated AVE of 17.72%. On the other hand, tariffs seem to matter most on the forward GVC participation in exports, where an increase of one unit percent in duties is related to a drop of 26.6% of the forward participation in exports. This fact should not be surprising. Indeed, the trade of intermediate goods can magnify the impact of tariffs on the economy, even more if they are at the origin of international multistage production (Antràs and De Gortari, 2020). Interestingly, the variable RTA shows a positive but not statistically significant coefficient, while the coefficients of other cultural, political, and distance-related variables are in line with those in columns (1) and (2).

In columns (4) to (6), I repeat the analysis considering only the manufacturing sectors[17]. Restricting the sample to specific sectors enables the comparison of the regulatory distance impact on GVC-related measures among different industries. For all specifications, the estimated elasticities for the regulatory distance index are higher than those in columns (1) to (3), with the highest impact on the forward GVC trade (the elasticity is – 0.103, s.e. = 0.018). Similarly, ad-valorem tariff equivalents are higher than those estimated over all sectors, with the highest AVE (176.36%) when the analysis is carried out on the backward GVC trade. Interestingly, compared to the analysis conducted over all sectors, we see lower elasticities for the variable Tariff, with coefficients ranging from – 0.07 (column 5) to – 0.141 (column 6). Concerning the rest of the coefficients, they are overall similar to those of specifications (1) to (3) in terms of magnitude and statistical significance. Finally, to check

[17] Manufacturing sectors belong to industries from 10 to 33 according to the ISIC Revision 4 Classification. See Table A2 for more information on the specific sectors.

the adequacy of the estimated models, I performed a set heteroskedasticity-robust Regression Equation Specification Error Test (RESET) (Ramsey, 1969). Essentially, the RESET tests for the correct specification of the conditional expectation, which is performed by checking the significance of an additional regressor constructed as $\hat{\beta}_y^{\,2}$, where $\hat{\beta}_y$ denotes the model's fitted values. Since it tests the null hypothesis of correct model specification, the model is considered misspecified whenever this coefficient is statistically significant. The corresponding p-values are reported at the bottom of Table 1, and, overall, they confirm the proper specification of the models.

# 6. Robustness and sensitivity analysis

This section presents the tests that I run to measure the robustness of the baseline results and their sensitivity to different model specifications. Firstly, I run the analysis with data for the dependent variables gathered from a different data source (World Input-Output Database). Secondly, I use panel data with intervals in order to allow for adjustment in trade flows. Then, I use contemporaneous values for the trade policy variables and test the model with different lag lengths. Finally, I employ the regulatory distance index while keeping the missing values.

As a first robustness check, I use data for total, backward, and forward GVC-related trade gathered from the World Input-Output Database (WIOD) for 40 countries across 21 sectors from 2000 to 2014[18]. As Jones et al. (2016) highlight, relevant differences exist between the official statistics provided by the ICIO tables. A first source of the differences among ICIO tables arises from the specific compilation methods and assumptions used to reconcile data from different sources and cope with data availability or reliability issues. Another reason lies in the way goods and services are broken down by end-use category in the ICIO table, which affects the results obtained for Input-Output indicators and explains some discrepancies between the data sources. Differences in data coverage between ICIO tables may also be at the origin of discrepancies observed with official statistics. For example, the inclusion, or not, of re-exports or processing trade in the data may result in the differences observed, especially for economies involved in such activities like Mexico, China, or Belgium. Therefore, this first robustness check tests whether the baseline results are robust to a different methodology used to aggregate GVC-related trade measures and a different country sample.

[18] Table A 5 and Table A 6 list, respectively, the sample of countries and the sample of sectors covered by this study using data from WIOD Release 2016.

Table 2 presents the results from the gravity model estimation. Columns (1) to (3) present the gravity model results on total, backward, and forward GVC-related trade, respectively. Column (1) shows a negative impact of bilateral regulatory distance (the elasticity equals – 0.034) on total GVC-related trade. With a p-value of 0.053, this coefficient is barely above the statistical significance threshold of 5% level.  For the remaining specifications (columns 2 and 3), the estimated regulatory distance index elasticities are in line in terms of sign and statistical significance with those of Table 1 but different in terms of magnitude and ad-valorem tariffs equivalents. However, this outcome should not be surprising since I estimate the model on a remarkably smaller sample. Concerning the models' specification, the RESET Ramsey Test rejects the null hypothesis of non-misspecification for the models with total and forward GVC-related trade as dependent variables. This outcome suggests that the inclusion of nonlinear functions, which can either be power terms or interaction terms, would be more advisable for these data. Despite this, the results in Table 2 demonstrate that baseline results are overall robust to different methodologies of construction of the dependent variables as well as to a different country sample.

As a second robustness check, I allow for adjustment in trade flows by using panel data with intervals instead of data pooled over consecutive years (Yotov et al., 2016). As introduced in Section 4, trade flows do not respond immediately to changes in trade policy. The challenge of adapting trade flows is even more pronounced in econometric specifications with fixed effects. As noted in Cheng and Wall (2005), fixed-effects estimation applied to data pooled over consecutive years has been criticized on the grounds that dependent and independent variables cannot fully adjust in a single year. For this reason, in the baseline model (Table 1), I include trade policy variables lagged by one year. However, the literature also offers different approaches to deal with this issue. For instance, Trefler (2004) conducts gravity analysis on panel data with 3-year intervals while Anderson and Yotov (2016) opt for 4-year intervals. Moreover, Olivero and Yotov (2012) demonstrate that gravity estimates obtained with 3-year and 5-year interval trade data are overall similar, while estimations performed with panel samples pooled over consecutive years produce suspicious estimates of the trade cost elasticity parameters.

For this study, I opt for 3-year intervals (2005, 2008, 2011, and 2014) to both account for adjustment in trade flows and preserve the estimation efficiency. Since I do not use lagged variables for these three models, I deal with the issue of reverse causality by including importer-exporter-sector fixed effects. Yotov et al. (2016) and Kinzius et a. (2019) show that

**Table 2:** gravity model estimation with data from WIOD (2016)

| Dependent variable | (1) Overall GVCp | (2) Backward GVCp | (3) Forward GVCp |
|---|---|---|---|
| ln(1 + RD) | -.034* | -.061*** | -.054** |
| | (.018) | (.019) | (.023) |
| ln(1 + tariff) | -.079*** | -.039* | -.126*** |
| | (.021) | (.022) | (.026) |
| RTA | .14*** | .216*** | .086 |
| | (.048) | (.046) | (.066) |
| Log Distance | -.906*** | -.876*** | -.927*** |
| | (.027) | (.029) | (.037) |
| Contiguity | .299*** | .324*** | .27*** |
| | (.032) | (.036) | (.041) |
| Common-language | .201*** | .176*** | .281*** |
| | (.043) | (.048) | (.058) |
| Common colonizer | 1.424*** | 1.411*** | 1.369*** |
| | (.211) | (.244) | (.195) |
| Religion proximity index | -.012 | -.024 | -.066 |
| | (.064) | (.065) | (.098) |
| Colonial-tie | -.03 | -.144 | -.082 |
| | (.119) | (.13) | (.141) |
| Common legal origin | .307*** | .31*** | .333*** |
| | (.025) | (.027) | (.03) |
| Legal origin changed | -.068 | -.151*** | -.078 |
| | (.043) | (.049) | (.054) |
| Same colonizer | -.276** | -.225** | -.423** |
| | (.116) | (.099) | (.167) |
| _cons | 13.509*** | 12.817*** | 12.966*** |
| Observations | 270128 | 270128 | 270052 |
| Pseudo $R^2$ | .925 | .93 | .92 |
| RESET Test | 0.000 | 0.451 | 0.000 |
| $AVE_{RD}$ | 54.35 | 385.68 | 53.43 |

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the WIOD database, 2016 version. Variables for RD, tariffs, and RTA are lagged by one year. Standard errors are clustered at the exporter–importer-sector level. All regressions include exporter-sector-year and importer-sector-year fixed effects. Standard errors are in parentheses. *Significance levels: *** p<.01, ** p<.05, * p<.1*

two major benefits are associated with using exporter–importer-sector fixed effects in gravity estimations. First, they absorb all time-invariant bilateral trade costs at the sector level, such as distance, a shared border, or specific industry linkages. Second, pair fixed effects account for the endogeneity of trade policy variables (Baier and Bergstrand, 2007). For this reason, this model specification can also be considered a further control for the endogeneity in the baseline estimation.

In Table 3, I present the results from the gravity model estimation using 3-year intervals. Columns (1) to (3) present the gravity model results on total, backward, and forward GVC-related trade, respectively. Concerning the regulatory distance index, the estimation shows positive and statistically significant coefficients at the 5% level (column 1) and 1% level (column 2), in line with the baseline results. However, the analysis of the forward linkages of exports (column 3) reveals a non-statistically significant effect of bilateral regulatory distance. Similarly, the dummy variable RTA shows non-statistically significant coefficients for all three specifications. Interestingly, the overall impact of regulatory distance is smaller on GVC-trade measures compared to the baseline. More precisely, the index coefficients for columns (1) and (2) are, respectively, 1.8% and 0.5% smaller than those reported in Table 1. Overall the results seem to be robust for the analysis of total and backward GVC-related trade, while the outcome of column (3) casts some doubts on the endogeneity of the regulatory distance effect on the forward GVC trade.

In Table 4, I present my third robustness check in which I test whether the choice of lags for the trade policies variables is driving the results. Using lags ensures that I account for changes in trade flows, which do not follow immediately but only after some time of adaptation. Since this practice is not standard in the literature, following Kinzius et al. (2019), I use contemporaneous trade policy variables as a robustness check (columns 1 to 3). As for the specification in Table 3, exporter-importer-sector fixed effects are included to control for endogeneity. Furthermore, as recommended in Yotov et al. (2016), I also perform the gravity analysis with alternative lag intervals (2-year lags) to test whether the lag length chosen in the baseline is driving the results (columns 4 to 6).

Column (1) shows that the impact of bilateral contemporaneous regulatory distance is 0.9% smaller in magnitude than lagged regulatory distance, providing further evidence that trade flows take time to adjust to changes in NTMs patterns. When we consider the backward linkages of bilateral-sectoral exports instead, contemporaneous and lagged regulatory distance have a similar impact (column 2). However, column (3) reveals a non-statistically significant effect of the regulatory distance index, suggesting that contemporaneous regulatory distance does not affect the forward GVC component of exports. In columns (4) to (6), I run the gravity model with trade policy variables lagged by two years. The negative effect of regulatory distance is smaller with a 2-year lag for all three components of bilateral sectoral exports than with a single-year lag, suggesting that the repercussions of dissimilarity in NTMs structures on GVC-related trade measures strongly decrease over time.

**Table 3:** gravity model estimation with 3-year time intervals

| Dependent variable | (1) Overall GVCp | (2) Backward GVCp | (3) Forward GVCp |
|---|---|---|---|
| ln(1 + RD) | -.034** | -.058*** | -.014 |
| | (.016) | (.016) | (.021) |
| ln(1 + tariff) | -.069*** | -.045*** | -.09*** |
| | (.01) | (.01) | (.014) |
| RTA | .006 | .027 | -.012 |
| | (.025) | (.025) | (.037) |
| _cons | 6.884*** | 6.3*** | 6.147*** |
| | (.039) | (.039) | (.057) |
| Observations | 271807 | 271801 | 269243 |
| Pseudo $R^2$ | .984 | .98 | .979 |
| RESET Test | 0.035 | 0.369 | 0.004 |
| $AVE_{RD}$ | 64.28 | 259.72 | 16.91 |

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer-sector level. All variables are in contemporaneous values. All regressions include exporter-sector-year, importer-sector-year, and exporter-importer-sector fixed effects. Standard errors are in parentheses. *Significance levels: *** p<.01, ** p<.05, * p<.1*

Interestingly, tariffs show similar behavior to that of regulatory distance. Indeed, when we consider the analysis conducted with contemporaneous tariff values, the impact is substantially smaller than that of 1-year lag tariffs. On the contrary, elasticities for the 2-years lagged tariffs are overall close to those of the 1-year lagged ones, supporting the idea that trade flows take time to adjust to changes in bilateral trade costs. Except for the specification reported in column (1), the models estimated with contemporaneous and 2-year lagged trade policies variables pass the RESET test, that is, the RESET test confirms the correct specification of the gravity equations. To sum up, the results are overall robust to the number of lags chosen for the analysis conducted on total and backward GVC-related trade. On the other hand, the regulatory distance effect on the forward GVC component of exports was not statistically significant in none of the two models.

As the fourth and last robustness check, I test whether the results are driven by the imputation method I choose to fulfill the missing values of the regulatory distance index. As explained in Section 3.3, the linear interpolation algorithm assumes that a variable *y* (the variable having missing observations) varies linearly with a variable *x* within gaps. To test the solidity of the findings despite the data imputation, I repeat the analysis for the gravity model baseline while keeping the missing observations of the variable regulatory distance index instead of fulfilling them.

**Table 4:** gravity model estimation with contemporaneous and 2-year lags trade policy variables

| Lag length in trade policy variables | No lags | | | 2-year lags | | |
|---|---|---|---|---|---|---|
| Dependent variable | (1) Overall GVCp | (2) Backward GVCp | (3) Forward GVCp | (4) Overall GVCp | (5) Backward GVCp | (6) Forward GVCp |
| ln(1 + RD) | -.041*** | -.063*** | -.011 | -.047*** | -.059*** | -.039* |
| | (.015) | (.014) | (.022) | (.016) | (.016) | (.021) |
| ln(1 + tariff) | -.06*** | -.038*** | -.081*** | -.166*** | -.1*** | -.263*** |
| | (.007) | (.008) | (.01) | (.02) | (.02) | (.027) |
| RTA | .039* | .043** | .033 | .097*** | .177*** | .032 |
| | (.021) | (.019) | (.034) | (.036) | (.037) | (.05) |
| Log Distance | | | | -.815*** | -.818*** | -.814*** |
| | | | | (.022) | (.024) | (.028) |
| Contiguity | | | | .296*** | .268*** | .333*** |
| | | | | (.03) | (.033) | (.035) |
| Common-language | | | | .153*** | .162*** | .14*** |
| | | | | (.037) | (.037) | (.049) |
| Common colonizer | | | | -.212* | .16* | -.457*** |
| | | | | (.113) | (.094) | (.161) |
| Religion proximity index | | | | -.027 | -.106* | .068 |
| | | | | (.055) | (.057) | (.078) |
| Colonial-tie | | | | .066 | .07 | .01 |
| | | | | (.086) | (.089) | (.108) |
| Common legal origin | | | | .256*** | .249*** | .279*** |
| | | | | (.024) | (.026) | (.031) |
| Legal origin changed | | | | -.097** | -.132*** | -.101* |
| | | | | (.04) | (.043) | (.053) |
| Same colonizer | | | | -.11 | -.117 | -.156 |
| | | | | (.079) | (.076) | (.107) |
| _cons | 6.794*** | 6.243*** | 6.019*** | 13.009*** | 12.479*** | 12.337*** |
| | (.037) | (.033) | (.058) | (.181) | (.199) | (.239) |
| Observations | 741837 | 741798 | 737757 | 596245 | 596206 | 596005 |
| Pseudo $R^2$ | .983 | .979 | .977 | .914 | .92 | .911 |
| RESET Test | 0.036 | 0.414 | 0.056 | 0.294 | 0.551 | 0.170 |
| $AVE_{RD}$ | 96.30 | 441.36 | 14.25 | 32.67 | 80.30 | 15.90 |

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer-sector level. All regressions include exporter-sector-year and importer-sector-year fixed effects. Regressions in columns (1) to (3) also include exporter-importer-sector fixed effects. Standard errors are in parentheses. *Significance levels: *** p<.01, ** p<.05, * p<.1*

Table 5 presents the results of this final sensitivity analysis. The regulatory distance index shows negative and statistically significant coefficients at the 1% level for all three specifications. Interestingly, for specifications (1) and (3), the regulatory distance elasticities are even higher when missing values are not imputed. This is especially true when I measure the effect on total and forward GVC-related trade, where the impact associated with a 1%

**Table 5:** gravity model estimation, RD index with missing values

| | (1) | (2) | (3) |
|---|---|---|---|
| Dependent variable | Overall GVCp | Backward GVCp | Forward GVCp |
| ln(1 + RD) | -.058*** | -.058*** | -.066*** |
| | (.016) | (.017) | (.02) |
| ln(1 + tariff) | -.171*** | -.099*** | -.268*** |
| | (.02) | (.02) | (.026) |
| RTA | .102*** | .181*** | .039 |
| | (.038) | (.037) | (.054) |
| Log Distance | -.811*** | -.835*** | -.795*** |
| | (.021) | (.022) | (.027) |
| Contiguity | .296*** | .262*** | .341*** |
| | (.027) | (.03) | (.03) |
| Common-language | .145*** | .151*** | .136*** |
| | (.037) | (.035) | (.051) |
| Common colonizer | -.187* | .185** | -.374** |
| | (.11) | (.089) | (.156) |
| Religion proximity index | .061 | -.006 | .109 |
| | (.052) | (.053) | (.07) |
| Colonial-tie | -.011 | -.044 | -.036 |
| | (.095) | (.095) | (.121) |
| Common legal origin | .25*** | .236*** | .276*** |
| | (.024) | (.024) | (.031) |
| Legal origin changed | -.116*** | -.15*** | -.128*** |
| | (.037) | (.038) | (.049) |
| Same colonizer | -.098 | -.105 | -.147 |
| | (.076) | (.068) | (.113) |
| _cons | 12.989*** | 12.626*** | 12.202*** |
| | (.175) | (.186) | (.234) |
| Observations | 481226 | 481203 | 480977 |
| Pseudo $R^2$ | .923 | .929 | .92 |
| RESET Test | 0.756 | 0.183 | 0.058 |
| $AVE_{RD}$ | 40.08 | 80.12 | 27.79 |

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer-sector level. Variables for RD, tariffs, and RTA are lagged by one year. All regressions include exporter-sector-year and importer-sector-year fixed effects. Standard errors are in parentheses. *Significance levels: *** p<.01, ** p<.05, * p<.1*

increase in bilateral regulatory distance index is, respectively, 0.6% and 2.3% higher than in the baseline. Similarly, ad-valorem tariff equivalents are also larger in magnitude for the not imputed version of the regulatory distance index when I test its impact on total and forward GVC trade, while it is slightly lower on backward GVC-related trade compared to the baseline results. To complete the analysis, I performed the same set of specification RESET tests performed before. The p-values of the heteroskedasticity-robust RESET tests at the bottom of Table 5 suggest that the null hypothesis of the proper model specification is not rejected and that the models are correctly specified for all three dependent variables. Altogether, the results demonstrate that neither the imputation of missing values nor the imputation technique chosen have driven the baseline results.

# 7. Policy implications and conclusion

This research aims to contribute to the trade literature by modeling the impact of bilateral regulatory distance in NTMs on the GVC components of countries' exports within a gravity model framework. Following Cadot et al. (2015), I built a regulatory distance index, which measures the heterogeneity in NTMs adopted between different country pairs. Then, I included estimates for the regulatory distance indicator, as well as a large array of control variables and trade directional fixed effects, in a set of gravity equations to estimate the effect that these variables have on the GVC-related components of countries' trade. Moreover, for each model specification, I calculated the ad-valorem tariff equivalent for the regulatory distance, that is, the ad-valorem tariff whose introduction would have generated the same impact as the regulatory distance in question. Measures of total, backward and forward GVC-related trade, which are the dependent variables of the gravity models, were constructed following the Borin and Mancini (2019) methodology of value-added decomposition of gross exports.

The empirical analysis indicates a negative and statistically significant relationship between bilateral regulatory distance and the GVC-related components of countries' exports. In particular, when the analysis is conducted across all sectors, the regulatory distance index registers the highest impact on backward GVC-related trade with an average elasticity of – 0.063 and an ad-valorem tariff equivalent of 96.31%. Instead, when I restrict the gravity analysis to the exports of manufacturing goods, the regulatory distance has the highest impact on the forward GVC-related trade with an average elasticity of – 0.103 and an AVE of 108.38%.

In order to assess the overall robustness of my findings, I conducted a broad set of sensitivity analyses. More precisely, I first tested the methodology with which the GVC-related trade measures are built and the country sample. Then, I adopted a different approach to take into account the adjustment in trade flows. I next tested the choice of lagged trade policies variables, the lags-length, as well as the potential endogeneity of the regressors. Finally, I checked whether the imputation technique to fulfill missing values drove the results for the variable of interest. Overall, the robustness tests I implemented confirm the solidity of the findings for the analysis performed on the total and backward GVC components of trade.

However, the specifications having forward GVC trade as a dependent variable did not pass part of the tests, casting doubts on the overall robustness of the regulatory distance effect on the forward GVC linkages of countries' exports.

Complementary to these analyses, this study also includes two additional models to assess whether an interaction exists between the impact of regulatory distance and the exporter's and the importer's development levels (see Annex B). The baseline equation (Eq. 7) is extended with a two-way interaction term between the regulatory distance index and the exporter's GNI per capita in the first gravity model. In contrast, the second model includes a three-way interaction between the regulatory distance index and the importers' and exporters' levels of development. Overall, the results suggest that the negative effect of regulatory distance is lower for exporters with higher levels of gross national income per capita. Also, the marginal effect of regulatory distance is more adverse for developing exporters addressing a low-middle or upper-middle compared to a high-income importing market.

It is worth highlighting that the empirical findings reported herein should be considered in light of some limitations. The first most obvious caveat of this research lies in its country coverage. Due to the complexity of generating and retrieving reliable data on GVC trade, this study covers only 59 economies, cutting off a large amount of small and less developed countries. For this reason, it might be complex to generalize these findings to all the low-income economies, for which regulatory distance might be even more costly in terms of GVCs participation (as partially shown in Annex B). Second, based on Cadot et al. (2015), this work employs a measure of total-bilateral dissimilarity in NTMs, i.e., the regulatory distance index. However, this indicator does not assess the bilateral regulatory distance at the sector level, and allowing the sectoral dimension of regulatory distance might benefit the analysis in terms of precision. Finally, although this work investigates heterogeneity in the regulatory distance at countries' income levels, it does not take into account other relevant dimensions such as countries' market size and their geographical position. Therefore, future studies should also consider these aspects in order to provide a more comprehensive understanding of the linkages by which dissimilarity in NTMs affects countries' GVC participation.

Nevertheless, the findings presented in this paper have important policy implications. Indeed, they demonstrate the substantial influence of heterogeneity in NTMs on GVC components of countries' exports, particularly on the total and backward GVC trade. It is worth pointing out that integration in GVCs itself is not a guarantee of higher income and growth. Indeed, low levels of exports diversification and sophistication, summed to a participation in the low value-added portions of GVCs, lead to the risk of being permanently confined to these segments (Fortunato and Razo, 2014). However, as Allard et al. (2016) highlight, scaling up in the GVC – increasing the share of foreign value-added in one country's exports – is associated with better chances to enhance structural transformation and economic growth. Also, the insertion into GVCs can boost positive spillovers into the domestic economy through backward linkages if the domestic sectors are competitive enough to contribute to the value chain. In this sense, this study provides shreds of evidence that high levels of regulatory distance might hamper the countries' attempt to climb up the GVCs and that harmonization and mutual recognition might be essential tools to reconcile the countries' needs of trade regulation and the aim of scaling international value chains.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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# Appendix A: Additional tables and figures

**Table A 1:** List of sample countries

| ISO alpha-3 | Country | ISO alpha-3 | Country |
|---|---|---|---|
| ARG | Argentina | JPN | Japan |
| AUS | Australia | KAZ | Kazakhstan |
| AUT | Austria | KHM | Cambodia |
| BEL | Belgium | KOR | Korea Republic |
| BGR | Bulgaria | LTU | Lithuania |
| BRA | Brazil | LUX | Luxembourg |
| BRN | Brunei Darussalam | LVA | Latvia |
| CAN | Canada | MAR | Morocco |
| CHE | Switzerland | MEX | Mexico |
| CHL | Chile | MLT | Malta |
| CHN | China | MYS | Malaysia |
| COL | Colombia | NLD | Netherlands |
| CRI | Costa Rica | NZL | New Zealand |
| CYP | Cyprus | PER | Peru |
| CZE | Czech Republic | PHL | Philippines |
| DEU | Germany | POL | Poland |
| DNK | Denmark | PRT | Portugal |
| ESP | Spain | ROU | Romania |
| EST | Estonia | RUS | Russia |
| FIN | Finland | SAU | Saudi Arabia |
| FRA | France | SGP | Singapore |
| GBR | United Kingdom | SVK | Slovak Republic |
| GRC | Greece | SVN | Slovenia |
| HKG | Hong Kong | SWE | Sweden |
| HUN | Hungary | THA | Thailand |
| IDN | Indonesia | TUN | Tunisia |
| IND | India | TUR | Turkey |
| IRL | Ireland | USA | United States |
| ISR | Israel | VNM | Vietnam |
| ITA | Italy | | |

Source: OECD ICIO Tables.

**Table A 2:** List of sample sectors

| TiVA industry code | Sector | ISIC Rev. 4 |
|---|---|---|
| D01T03 | Agriculture, forestry and fishing | From 01 to 03 |
| D05T06 | Mining and extraction of energy-producing products | 05, 06 |
| D07T08 | Mining and quarrying of non-energy producing products | 07, 08 |
| D09 | Mining support service activities | 09 |
| D10T12 | Food products, beverages, and tobacco | 10, 11, 12 |
| D13T15 | Textiles, wearing apparel, leather and related products | 13, 14, 15 |
| D16 | Wood and products of wood and cork | 16 |
| D17T18 | Paper products and printing | 17, 18 |
| D19 | Coke and refined petroleum products | 19 |
| D20T21 | Chemicals and pharmaceutical products | 20, 21 |
| D22 | Rubber and plastic products | 22 |
| D23 | Other non-metallic mineral products | 23 |
| D24 | Basic metals | 24 |
| D25 | Fabricated metal products | 25 |
| D26 | Computer, electronic and optical products | 26 |
| D27 | Electrical equipment | 27 |
| D28 | Machinery and equipment, nec | 28 |
| D29 | Motor vehicles, trailers and semi-trailers | 29 |
| D30 | Other transport equipment | 30 |
| D31T33 | Other manufacturing; repair, and installation of machinery and equipment | 31, 32, 33 |
| D35T39 | Electricity, gas, water supply, sewerage, waste and remediation services | 35,36, 37, 38, 39 |

Source: OECD ICIO Tables.

**Table A 3:** Summary statistics

**A3.a:** Summary statistics, full dataset

| | N | Mean | Std. Dev. | Min | Max | Skewness |
|---|---|---|---|---|---|---|
| Total GVCp | 790454 | 51.203 | 431.563 | 0.000 | 62320.387 | 47.483 |
| Backward GVCp | 790415 | 24.444 | 254.913 | 0.000 | 39311.383 | 68.278 |
| Forward GVCp | 790482 | 19.556 | 182.127 | 0.000 | 25558.621 | 42.842 |
| RD index | 601398 | 12.053 | 8.508 | 0.000 | 29.872 | -0.336 |
| RD index (imputed values) | 789600 | 13.421 | 8.095 | 0.000 | 29.872 | -0.613 |
| Log RD index | 601398 | 2.050 | 1.284 | 0.000 | 3.430 | -0.872 |
| Log RD index (imputed values) | 789600 | 2.252 | 1.187 | 0.000 | 3.430 | -1.247 |
| Effectively applied tariff | 753942 | 5.219 | 12.226 | 0.000 | 1425.050 | 17.705 |
| Log Tariff | 753942 | 1.070 | 1.145 | 0.000 | 7.263 | 0.671 |
| Log Distance | 790482 | 8.502 | 0.998 | 5.081 | 9.886 | -0.778 |
| Contiguity | 790482 | 0.038 | 0.191 | 0.000 | 1.000 | 4.833 |
| Common-language | 790482 | 0.089 | 0.285 | 0.000 | 1.000 | 2.878 |
| Common colonizer | 790482 | 0.023 | 0.151 | 0.000 | 1.000 | 6.309 |
| Religion proximity index | 763686 | 0.169 | 0.263 | 0.000 | 0.988 | 1.633 |
| Colonial-tie | 790482 | 0.012 | 0.110 | 0.000 | 1.000 | 8.859 |
| Common legal origin | 790482 | 0.321 | 0.467 | 0.000 | 1.000 | 0.765 |
| Legal origin changed | 790482 | 0.133 | 0.339 | 0.000 | 1.000 | 2.166 |
| Same colonizer | 790020 | 0.043 | 0.202 | 0.000 | 1.000 | 4.524 |
| RTA | 790482 | 0.418 | 0.493 | 0.000 | 1.000 | 0.333 |
| GNI per capita (exporter) | 790482 | 24588 | 19910 | 460 | 88740 | 0.771 |

Notes: Summary statistics are computed over the whole timespan (2005 – 2015). Total GVCp refers to total GVC-related trade, Backward GVCp refers to Backward GVC-related trade, and Forward GVCp refers to Forward GVC-related trade. Source: Authors' calculation.

**A3.b:** Summary statistics, 3-year time intervals

| | N | Mean | Std. Dev. | Min | Max | Skewness |
|---|---|---|---|---|---|---|
| Total GVCp | 287440 | 53.051 | 437.840 | 0.000 | 61343.984 | 44.073 |
| Backward GVCp | 287434 | 25.365 | 255.398 | 0.000 | 37814.605 | 63.571 |
| Forward GVCp | 287448 | 20.158 | 187.975 | 0.000 | 24345.078 | 41.010 |
| RD index | 175980 | 10.337 | 8.582 | 0.000 | 29.026 | 0.010 |
| RD index (imputed values) | 287028 | 13.338 | 8.111 | 0.000 | 29.026 | -0.590 |
| Log RD index | 175980 | 1.820 | 1.333 | 0.000 | 3.402 | -0.535 |
| Log RD index (imputed values) | 287028 | 2.244 | 1.187 | 0.000 | 3.402 | -1.230 |
| Effectively applied tariff | 277704 | 5.385 | 11.369 | 0.000 | 408.090 | 6.995 |
| Log Tariff | 277704 | 1.090 | 1.156 | 0.000 | 6.014 | 0.658 |
| RTA | 287448 | 0.415 | 0.493 | 0.000 | 1.000 | 0.344 |

Notes: The summary statistics are computed over the same years of the robustness check presented in Table 3, namely, 2005, 2008, 2011, and 2014. Total GVCp refers to total GVC-related trade, Backward GVCp refers to Backward GVC-related trade, and Forward GVCp refers to Forward GVC-related trade. Source: Authors' calculation.

**Table A 4:** Summary of missing values

| | Missing | Total | Percent missing |
|---|---|---|---|
| Total GVCp | 28 | 790,482 | 0.000 |
| Backward GVCp | 67 | 790,482 | 0.010 |
| Forward GVCp | 0 | 790,482 | 0.000 |
| RD index | 189,084 | 790,482 | 23.920 |
| RD index (imputed values) | 882 | 790,482 | 0.110 |
| Log RD index | 189,084 | 790,482 | 23.920 |
| Log RD index (imputed values) | 882 | 790,482 | 0.110 |
| Effectively applied tariff | 36,540 | 790,482 | 4.620 |
| Log Tariff | 36,540 | 790,482 | 4.620 |
| Log Distance | 0 | 790,482 | 0.000 |
| Contiguity | 0 | 790,482 | 0.000 |
| Common-language | 0 | 790,482 | 0.000 |
| Common colonizer | 0 | 790,482 | 0.000 |
| Religion proximity index | 26,796 | 790,482 | 3.390 |
| Colonial-tie | 0 | 790,482 | 0.000 |
| Common legal origin | 0 | 790,482 | 0.000 |
| Legal origin changed | 0 | 790,482 | 0.000 |
| Same colonizer | 462 | 790,482 | 0.060 |
| RTA | 0 | 790,482 | 0.000 |
| GNI per capita (exporter) | 0 | 790,482 | 0.000 |

Notes: The summary of missing values is computed over the whole timespan (2005 – 2015). Source: Authors' calculation.

**Table A 5:** WIOD data, country coverage

| ISO alpha-3 | Country | ISO alpha-3 | Country |
|---|---|---|---|
| AUS | Australia | IND | India |
| AUT | Austria | IRL | Ireland |
| BEL | Belgium | ITA | Italy |
| BGR | Bulgaria | JPN | Japan |
| BRA | Brazil | KOR | Korea Republic |
| CAN | Canada | LTU | Lithuania |
| CHE | Switzerland | LUX | Luxembourg |
| CHN | China | LVA | Latvia |
| CYP | Cyprus | MEX | Mexico |
| CZE | Czech Republic | MLT | Malta |
| DEU | Germany | NLD | Netherlands |
| DNK | Denmark | POL | Poland |
| ESP | Spain | PRT | Portugal |
| EST | Estonia | ROU | Romania |
| FIN | Finland | RUS | Russia |
| FRA | France | SVK | Slovak Republic |
| GBR | United Kingdom | SVN | Slovenia |
| GRC | Greece | SWE | Sweden |
| HUN | Hungary | TUR | Turkey |
| IDN | Indonesia | USA | United States |

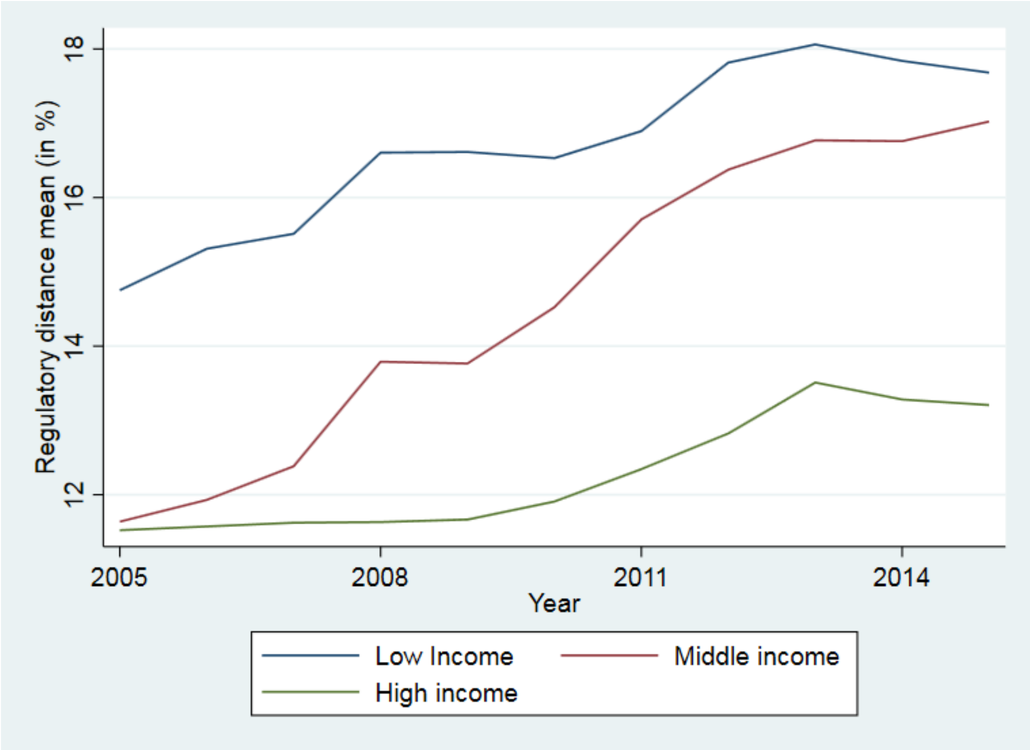
Source: World Input-Output Database; WIOD Data, 2016 Release.

**Table A 6:** WIOD data, sector coverage

| WIOD sector | Industry | ISIC Rev. 4 |
|---|---|---|
| Crop and animal production, hunting and related service activities | Agriculture, forestry and fishing | 01 |
| Fishing and aquaculture | Agriculture, forestry and fishing | 03 |
| Mining and quarrying | Mining and quarrying | From 05 to 09 |
| Manufacture of food products, beverages and tobacco products | Manufacturing | From 10 to 12 |
| Manufacture of textiles, wearing apparel and leather products | Manufacturing | From 13 to 15 |
| Manufacture of wood and of products of wood and cork | Manufacturing | 16 |
| Manufacture of paper and paper products | Manufacturing | 17 |
| Manufacture of coke and refined petroleum products | Manufacturing | 19 |
| Manufacture of chemicals and chemical products | Manufacturing | 20 |
| Manufacture of basic pharmaceutical products | Manufacturing | 21 |
| Manufacture of rubber and plastic products | Manufacturing | 22 |
| Manufacture of other non-metallic mineral products | Manufacturing | 23 |
| Manufacture of basic metals | Manufacturing | 24 |
| Manufacture of fabricated metal products, except machinery and equipment | Manufacturing | 25 |
| Manufacture of computer, electronic and optical products | Manufacturing | 26 |
| Manufacture of electrical equipment | Manufacturing | 27 |
| Manufacture of machinery and equipment n.e.c. | Manufacturing | 28 |
| Manufacture of motor vehicles, trailers and semi-trailers | Manufacturing | 29 |
| Manufacture of other transport equipment | Manufacturing | 30 |
| Manufacture of furniture, other manufacturing | Manufacturing | 31 and 32 |
| Repair and installation of machinery and equipment | Manufacturing | 33 |
| Electricity, gas, steam and air conditioning supply | Electricity, gas, steam and air conditioning supply | 35 |

Source: World Input-Output Database; WIOD Data, 2016 Release.

**Figure A 1:** Development of regulatory distance per exporter income-group




Notes: the bilateral regulatory distance is averaged among all the trade partners for each income group. Following the World Bank Atlas method, exporters are classified by GNI per capita. Source: Author's calculation.

## Appendix B: Gravity analysis by income group

This extra section addresses the question of whether the regulatory distance impact might be associated with the exporters' and the importers' income levels. The trade literature provides some evidence of differences in the pattern of NTMs and their impact on trade, according to the countries' level of development. Insightful in this sense is the contribution provided by Dolabella (2020). In his work, the author selects a gravity framework to decompose the impact of technical measures (i.e., TBT and SPS) across income country groups, finding that exporters from least developed nations (low and lower-middle income countries) are the most affected by a new TBT and that high-income countries impose the most restrictive technical measures. Similarly, Ghodsi et al. (2017) estimate the trade effects of NTMs for more than 100 countries with a gravity approach. The authors find an intense concentration of NTMs among upper-middle and high-income countries, while simultaneously, these countries are also the most frequently targeted by NTMs. Moreover, they discover that the trade-impeding effects of SPS measures decrease with higher income levels. In contrast to the two previous studies, which consider NTMs in cumulative terms, Nabeshima and Obashi (2019) analyze how the impact of additional regulatory compliance requirements changes by destination and origin country income groups. Their findings suggest that additional regulatory burdens faced by exporters when serving the less-developed countries' markets reduce the exports from other less-developed countries but do not affect those from developed countries. Instead, the regulatory burdens in serving the developed country's market restrict the trade flow originating from any country regardless of the income level.

To the best of my knowledge, no study has disentangled the impact of regulatory dissimilarities on the GVC-related trade by country income group. Therefore, this exercise intends to contribute to the literature by estimating how the effect of regulatory distance on GVC trade is related to the countries' development levels. More specifically, I build two additional models by including two-way and three-way interaction terms to the baseline gravity equation, i.e., Eq. (7). The first model estimates the simple relationship between the regulatory distance index and the exporter's development level, proxied by the GNI per capita. Equation (9) formalizes the first specification:

$$\begin{aligned} GVC_{ijt}^{k} = exp[\, & \beta_0 + \beta_1 \ln(1 + RD_{ijt-1}) + \beta_2 \left(\ln(1 + RD_{ijt-1}) \times GNI_{it}\right) \\ & + \beta_3 \ln\left(1 + Tariff_{ijt-1}^{k}\right) + \beta_4\, RTA_{ijt-1} + \beta_5 \ln(Dist_{ij}) \\ & + \theta_{ij} + \delta_{it}^{k} + \gamma_{jt}^{k} \,] \times \varepsilon_{ijt}^{k} \end{aligned} \tag{9}$$

Where $\ln(1+ RD_{ijt-1}) \times GNI_{it}$ is a two-way interaction term between the log of regulatory distance index in time $t$ – 1 and $GNI_{it}$, which corresponds to the Gross National Income per capita of exporter $i$ in year $t$. The rest of the equation is identical in terms of variables and interpretation to the baseline Eq. (7). According to this specification, a positive value for the interaction term coefficient would imply that the higher the exporter's GNI per capita, the less negative (or more positive) the effect of bilateral regulatory distance.

In the second model, I extend the analysis by interacting the relationship between the regulatory distance index with the destination and the origin countries' levels of development. Based on Eq. (7), I propose a three-way gravity model:

$$\begin{aligned} GVC_{ijt}^{k} = exp[\, & \beta_0 + \beta_1 \ln(1+ RD_{ijt-1}) \\ & + \beta_2 (\ln(1+ RD_{ijt-1}) \times Developing_{it} \times Income\ Class_{jt}) \\ & + \beta_3 \ln\left(1 + Tariff_{ijt-1}^{k}\right) + \beta_4 RTA_{ijt-1} + \beta_5 \ln(Dist_{ij}) \\ & + \theta_{ij} + \delta_{it}^{k} + \gamma_{jt}^{k} \,] \times \varepsilon_{ijt}^{k} \end{aligned} \tag{10}$$

Where the term $\ln(1+ RD_{ijt-1}) \times Developing_{it} \times Income\ Class_{jt}$ is a three-way interaction between the log of regulatory distance index in time $t$ – 1, the dummy variable $Developing_{it}$, which equals one if the exporter is classified as a developing country in year $t$ and 0 otherwise[19], and the categorical variable $Income\ Class_{jt}$ that classifies the importing country as either low (L), lower-middle (LM), upper-middle (UM), or high (H) income economy, following the World Bank's income classification. Moreover, the model also includes the main effects of the regulatory distance index and the variables used as moderators, as well as the two-way interaction among them. However, for the sake of simplicity, they are not presented in this paper. The rest of the equation is identical in terms of variables and interpretation to the baseline Eq. (7). As base categories for the interaction term, I opted for "non-developing exporter" for the dummy variable $Developing_{it}$ and low-income importer group for the categorical variable $Income\ Class_{jt}$. Given this particular specification, a negative coefficient would imply that a GVC-trade measure from a developing exporter, oriented toward an importing market belonging to either LM, UM, or H income groups, is on average more negatively affected than that of a low-income importing market.

[19] More specifically, the variable $Developing_{it}$ equals one if the exporting market is either a low-income, lower-middle and upper-middle country, while it equals zero if the exporting market is an high-income economy, according to the World Bank's income classification.

Table A 7 reports the results from the gravity models estimation. Columns (1) to (3) present the gravity model results from Eq (9). By looking at the specification in columns (1) and (2), we see that the interaction terms between the regulatory distance index and the exporters' GNI per capita are statistically significant at the 1% significance level, which justifies the inclusion of the terms in the model. Also, in both model specifications, the coefficients are positive, meaning that exporters with higher levels of GNI per capita suffer less from the negative effect of regulatory distance. On the contrary, once the analysis is conducted on the forward GVC-related trade, the interaction term shows a positive but no longer statistically significant coefficient, suggesting that this data cannot tell a meaningful relationship between forward GVC-trade and the exporter's income level. Finally, the p-values of the RESET tests at the bottom of Table A 7 suggest the adequate specifications of the models in columns (1) to (3).

Figure A 2 uses the results of columns (1) to (3) in Table A 7 to plot the average marginal effect of regulatory distance on the three outcome variables, conditional to the exporters' GNI per capita. The horizontal axes measure the different levels of GNI per capita taken into account. The first quadrant shows that regulatory distance has the most negative impact on GVC-related trade for the least developed exporters, while its effect becomes more positive as the exporter's GNI per capita increases. Indeed, the marginal effect of regulatory distance is – 7.4% for exporters with a GNI per capita of 500 USD, and it becomes increasingly positive until reaching + 5.8% for destination economies with a GNI per capita of 80 thousand USD.  However, the marginal effect is statistically significant only for those exporters with a GNI per capita below 40 thousand USD and above 70 thousand USD. Similarly, the second quadrant reveals that the marginal effects of regulatory distance range from – 4.7% for exporters with a GNI per capita of 500 USD to a + 6.5% for the most developed exporters. In this case, the marginal effect is significant at all exporter's income levels except for the 50 thousand USD level. The third quadrant shows that the marginal effect is negative and statistically significant at the 5% level for those exporters with a lower level of GNI per capita (up to 40 thousand USD), while it loses significance as the GNI per capita rises to higher income levels.

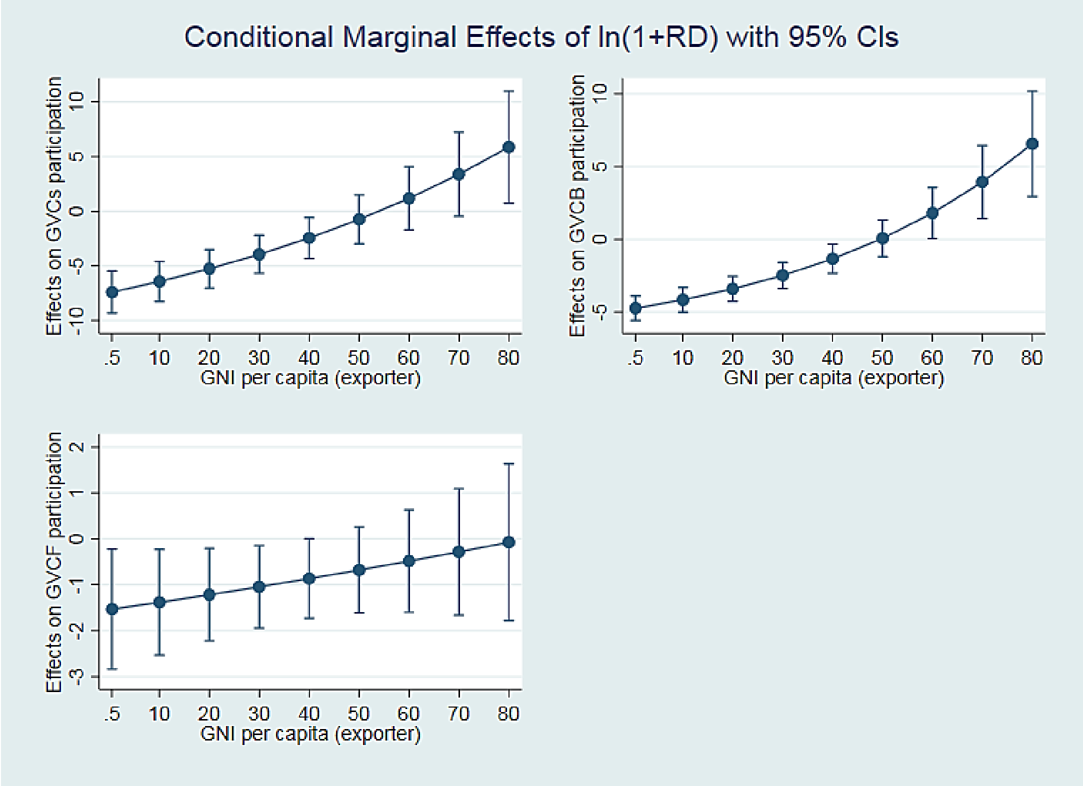
From an economic point of view, these findings suggest that dissimilarity in NTMs constitutes a relatively higher barrier to GVC participation in low-income countries than in middle and high-income countries. There might be several underlying reasons to explain this fact. Firstly, regulatory distance can be viewed as an additional cost of compliance that firms in exporting countries face to sell their products in a particular importing market. In this sense,

**Table A 7:** Gravity model analysis with two-way and three-way interaction terms

| Model considered | Equation (9) | | | Equation (10) | | |
|---|---|---|---|---|---|---|
| Dependent variable | (1) Overall GVCp | (2) Backward GVCp | (3) Forward GVCp | (4) Overall GVCp | (5) Backward GVCp | (6) Forward GVCp |
| ln(1 + RD) | -.159*** | -.229*** | -.078** | -.331*** | -.26*** | -.324*** |
| | (.024) | (.025) | (.037) | (.096) | (.09) | (.115) |
| ln(1 + RD) × GNI | .003*** | .005*** | .001 | | | |
| | (.001) | (.001) | (.001) | | | |
| ln(1 + tariff) | -.167*** | -.096*** | -.267*** | -.165*** | -.095*** | -.262*** |
| | (.02) | (.02) | (.027) | (.019) | (.019) | (.027) |
| RTA | .111*** | .195*** | .046 | .143*** | .235*** | .074 |
| | (.036) | (.036) | (.05) | (.037) | (.037) | (.054) |
| Log Distance | -.811*** | -.818*** | -.805*** | -.799*** | -.806*** | -.797*** |
| | (.022) | (.023) | (.027) | (.022) | (.024) | (.027) |
| Contiguity | .304*** | .28*** | .338*** | .322*** | .299*** | .352*** |
| | (.029) | (.032) | (.034) | (.029) | (.033) | (.034) |
| Common-language | .146*** | .152*** | .138*** | .149*** | .145*** | .143*** |
| | (.037) | (.037) | (.049) | (.036) | (.038) | (.049) |
| Common colonizer | -.229** | .157* | -.467*** | -.266** | .114 | -.478*** |
| | (.116) | (.093) | (.163) | (.118) | (.094) | (.166) |
| Religion proximity | -.053 | -.147*** | .053 | .002 | -.072 | .08 |
| index | (.055) | (.056) | (.078) | (.056) | (.057) | (.079) |
| Colonial-tie | .075 | .054 | .019 | .125 | .132 | .048 |
| | (.087) | (.091) | (.107) | (.083) | (.085) | (.105) |
| Common legal origin | .258*** | .251*** | .285*** | .249*** | .243*** | .275*** |
| | (.024) | (.026) | (.031) | (.025) | (.027) | (.032) |
| Legal origin changed | -.104*** | -.147*** | -.107** | -.11*** | -.152*** | -.113** |
| | (.04) | (.042) | (.053) | (.039) | (.042) | (.052) |
| Same colonizer | -.106 | -.12 | -.152 | -.104 | -.105 | -.152 |
| | (.079) | (.075) | (.108) | (.079) | (.076) | (.107) |
| ln(1 + RD) × Developing × Income Class | | | | | | |
| 1 LM | | | | -.461*** | -.456*** | -.445** |
| | | | | (.164) | (.177) | (.179) |
| 1 UM | | | | -.567*** | -.349** | -.736*** |
| | | | | (.163) | (.168) | (.188) |
| 1 H | | | | -.541*** | -.336** | -.613*** |
| | | | | (.154) | (.161) | (.177) |
| _cons | 13.01*** | 12.555*** | 12.251*** | 12.374*** | 12.012*** | 11.617*** |
| | (.179) | (.194) | (.235) | (.215) | (.233) | (.269) |
| Observations | 657981 | 657943 | 657687 | 657981 | 657943 | 657687 |
| Pseudo $R^2$ | .914 | .921 | .912 | .915 | .921 | .912 |
| RESET Test | 0.374 | 0.279 | 0.125 | 0.125 | 0.962 | 0.960 |

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer-sector level. Variables for RD, tariffs, and RTA are lagged by one year. All regressions include exporter-sector-year and importer-sector-year fixed effects. Standard errors are in parentheses. *Significance levels: *** p<.01, ** p<.05, * p<.1*

**Figure A 2:** Average marginal effects of regulatory distance by exporter' GNI per capita




Notes: The average marginal effects are plotted with 95 percent confidence intervals. GVCs refers to total GVC-related trade (or GVCs participation), GVCB refers to Backward GVC-related trade (or backward GVCs participation), and GVCF refers to Forward GVC-related trade (or forward GVCs participation). GNI per capita is measured in thousands of US current dollars. Source: Author's calculation.

conformity verification costs are relatively higher for developing countries and small producers, as they are often fixed costs and not proportionate to the value of the exports (contrary to tariff). However, the reasons behind the more considerable impact of regulatory distance on lower-income countries do not only lie in compliance costs. Indeed, a higher prevalence of NTMs addresses the sectors of export mainly interested by developing countries, such as agriculture and apparel. Therefore, regulatory distance costs also have a relatively higher weight for the low-income countries' exports basket (UNCTAD, 2018).

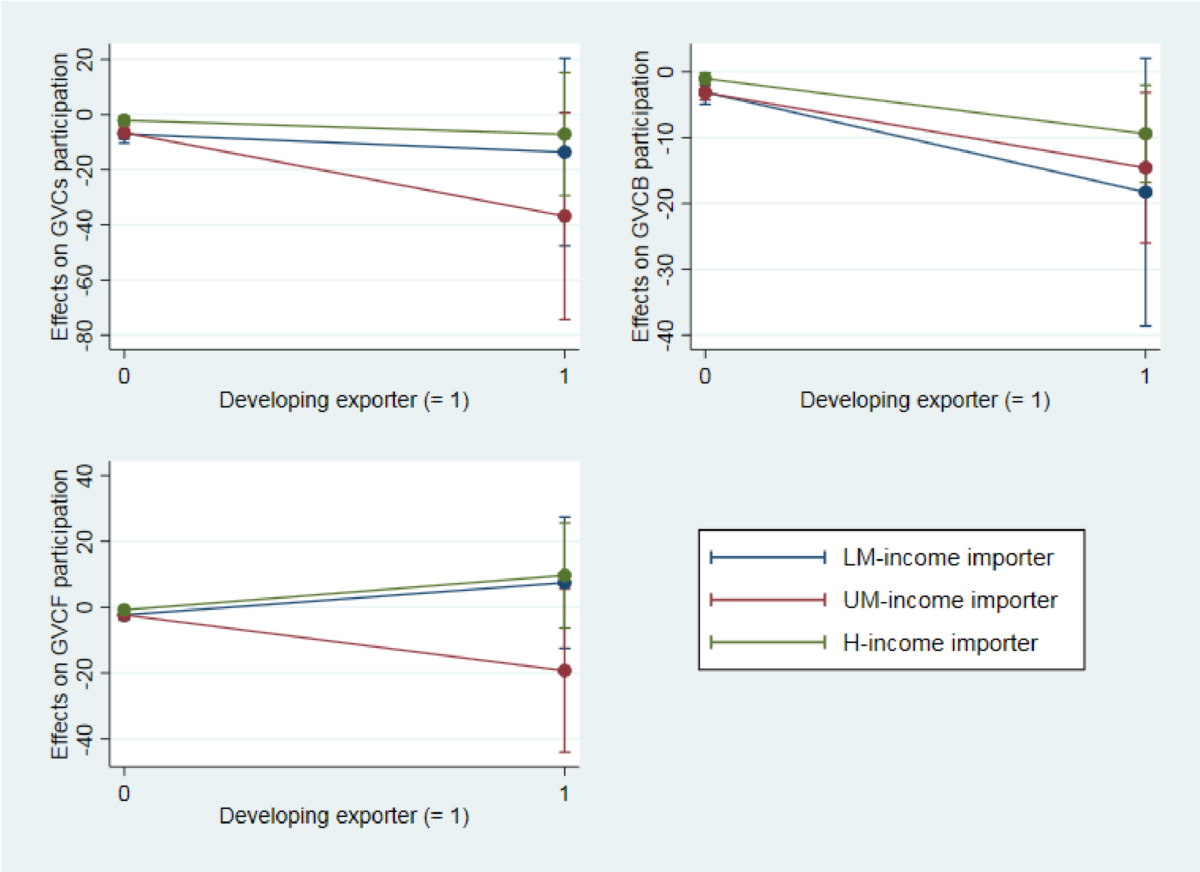
Columns (4) to (6) of Table A 7 present the gravity model results from Eq (10), which includes the interaction between regulatory distance and exporters' and importers' income levels. Interestingly, for all three specifications, we find that when the bilateral regulatory distance rises, the value of GVC-related trade measures from developing countries toward low-middle, upper-middle, and high-income importers are lower relative to low-income importers (the baseline). These findings support the idea that the impact of regulatory distance depends not only on the exporters' traits but also on the importing market's level of development. Finally, the models estimated with the three-way interaction passed the RESET test, that is, the RESET test confirms the correct specification of the gravity equations.

Figure A 3 uses the results of columns (4) to (6) in Table A 7 to plot the marginal effects of regulatory distance on developing exporters' GVC trade measures at the different levels of importers' income. The horizontal axes distinguish whether the exporting economy is classified as developing (= 1) or developed (= 0). The first quadrant shows that the marginal effect of regulatory distance on GVC-related trade is significantly negative for high-income countries regardless of the importing market's level of income, strongly negative (-36.8%), and statistically significant (p-value = 0.055) for developing countries addressing an upper-middle income market. By contrast, the marginal effect loses significance when developing countries serve low-middle and high-income importing markets. The second quadrant reveals that the marginal effect of regulatory distance on backward GVC trade is overall negative and statistically significant for both developing and developed exporters, regardless of the importing market's income level[20]. In this case, we see regulatory distance having the most substantial effect (– 18.2%) on developing exporters when they trade with low-middle income importers. The third quadrant shows that the marginal effect of regulatory distance on the forward GVC trade is negative and statistically significant at the 5% level only for high-income economies independently of the trade partner. By contrast, the marginal effect estimated for the developing exporters is not statistically significant.

These findings demonstrate that the impact of regulatory distance on GVC-trade measures is not homogenous but is, at least, associated with the trade partners' level of development. Interestingly, we see more negative marginal effects for developing (low-middle and upper-middle income) than developed exporting markets. This fact is especially true when we look at the total GVC-related trade, where the marginal effect of regulatory distance for developing countries that address an upper-middle income market is remarkably negative. Similarly, when we consider the backward GVC trade, the marginal effect of regulatory distance for a developing exporter touches almost – 20%, and it is approximately – 15% for low-middle and upper-middle income importing economies, respectively.

[20] Although the marginal effect for developing exporters interacting with low-income importers, presents a p-value of 0.078.

**Figure A 3:** Average marginal effects of regulatory distance by exporter's and importer's level of income




Notes: The average marginal effects are plotted with 95 percent confidence intervals. GVCs refers to total GVC-related trade (or GVCs participation), GVCB refers to Backward GVC-related trade (or backward GVCs participation), and GVCF refers to Forward GVC-related trade (or forward GVCs participation). Following the World Bank Atlas method, exporters are classified by GNI per capita. Source: Author's calculation.

The policy implications of these results are particularly relevant in the context of regional value chains and South-South integration. Indeed, especially for the least-developed economies, regional value chains are easier to penetrate, less resource-intensive, and less controlled by leading firms than international value chains. Moreover, increasing intra-regional trade, especially intra-industry trade, can reduce external output shocks and is a key to a successful penetration in GVCs (Brixiov et al., 2015). However, as this section shows, the bilateral regulatory distance among developing countries might be a considerable barrier for non-high income economies willing to build and climb production networks.